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Title: APPARATUS FOR DTECTING DETERIORATION OF AIR-FUEL RATIO SENSOR

VERIFIED TRANSLATION OF PRIORITY DOCUMENT

The undersigned, of the below address, hereby certifies that he/she well knows both the English and Japanese languages, and that the attached is an accurate translation into the English language of the Certified Copy, filed for this application under 35 U.S.C. Section 119 and/or 365, of:

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[Title of the Invention] APPARATUS OF DETECTING DETERIORATION OF AIR-FUEL RATIO DETECTING APPARATUS

[Scope of Claim]

[Claim 1] An apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus, said deterioration detecting apparatus comprising:

air-fuel ratio detecting means constituted by arranging an electrode to a solid electrolyte element for detecting an air-fuel ratio in an emission gas from an engine;

temperature adjusting means for adjusting a temperature of the solid electrolyte element in the air-fuel ratio detecting means to a predetermined temperature; and

air-fuel ratio detection deterioration detecting means for detecting a deterioration of the air-fuel ratio detecting means by comparing outputs of the air-fuel ratio detecting means when the temperature of the solid electrolyte element is adjusted at least to two different temperatures by the temperature adjusting means.

[Claim 2] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to Claim 1, wherein the air-fuel ratio detection deterioration detecting means detects the deterioration of the air-fuel ratio detecting means by comparing the outputs of the air-fuel ratio detecting means when the temperature of the solid electrolyte is adjusted at least to two different temperatures by the temperature adjusting means in a same operating condition.

[Claim 3] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to Claim 1 or 2, wherein the air-fuel ratio detection deterioration detecting means detects the deterioration of the air-fuel ratio detecting means by comparing the outputs of the air-fuel ratio detecting means relative to predetermined variations of the air-fuel ratio when the temperature of the solid electrolyte element is adjusted at least to two different temperatures by the temperature adjusting means.

[Claim 4] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to Claim 1, wherein the air-fuel ratio detection deterioration detecting means detects the deterioration of the air-fuel ratio detecting means by comparing a response of the air-fuel ratio detecting means relative to predetermined variations of the air-fuel ratio or a parameter related to an output characteristic with respect to the emission gas when the temperature of the solid electrolyte element is adjusted at least to two different temperatures by the temperature adjusting means.

[Claim 5] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to Claim 4, wherein the response or the parameter related to the output characteristic with respect to the emission gas is at least one of an output variation width, an output integrated value, an output differential value, an integrated value of the output differential value, an output period and an output frequency of the air-fuel ratio detecting means.

[Claim 6] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to any one of Claims 1 through 5, wherein the temperature adjusting means estimates the temperature of the solid electrolyte element by detecting an internal resistance of the air-fuel ratio detecting means and adjusts the temperature of the solid electrolyte element based on the estimated temperature.

[Claim 7] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to Claim 6, wherein the temperature adjusting means determines a heat amount for adjusting the temperature of the solid electrolyte element in accordance with an operating condition.

[Claim 8] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to any one of Claims 1 through 7, wherein the temperature adjusting means supplies or stops the heat amount for adjusting the temperature of the solid electrolyte element under a predetermined operating condition.

[Claim 9] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to any one of Claims 1 through 8, wherein the air-fuel ratio detecting means is installed downstream from a catalyst.

[Claim 10] The apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus according to any one of Claims 1 through 9, further comprising:

temperature adjusting failure detecting means for detecting a failure of the temperature adjusting means;

wherein the air-fuel ratio detection deterioration detecting means detects the deterioration of the air-fuel ratio detecting means only when the failure is not detected by the temperature adjusting failure detecting means.

[Detailed Description of the Invention]

[Technical Field of the Invention]

The present invention relates to an air-fuel ratio detecting apparatus, particularly to a deterioration-detecting apparatus of an air-fuel ratio detecting apparatus for diagnosing a deterioration of a downstream air-fuel ratio sensor arranged downstream from a catalyst, in details, to an apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus capable of detecting a deterioration of a downstream air-fuel ratio sensor at early time and accurately.

[Prior Art]

In a related art, there is known a constitution of arranging oxygen sensors respectively upstream and downstream from a catalyst interposed to an emission system of an engine. Further, in such a constitution, an air-fuel ratio feedback correction coefficient is set based on an output value of the extreme oxygen sensor arranged upstream from the catalyst and an air-fuel ratio is controlled such that an air-fuel ratio upstream from the catalyst becomes a target air-fuel ratio. Further, there is known a so-to-speak dual O_2 air-fuel ratio control achieving proper formation of an air-fuel ratio by correcting the air-fuel ratio feedback correction coefficient based on an output value of the downstream oxygen sensor arranged downstream from the catalyst.

Meanwhile, in such a dual O_2 air-fuel ratio control system, when the respective oxygen sensors are deteriorated, response of the oxygen sensors is deteriorated and therefore, proper air-fuel ratio control is deteriorated.

Further, in the above-described dual O_2 air-fuel ratio control system, a deterioration of the catalyst is diagnosed by comparing outputs of the two oxygen sensors provided upstream and downstream from the catalyst. Therefore, when the respective oxygen sensors are deteriorated, accuracy of diagnosing the deterioration of the catalyst using the oxygen sensors is also deteriorated and therefore, it is necessary to detect the deterioration of the air-fuel ratio sensors.

At this occasion, since the upstream oxygen sensor is arranged upstream from the catalyst, an oxygen concentration in emission gas emitted from the engine is directly detected. Therefore, when a variation of the air-fuel ratio is brought about, the upstream oxygen sensor immediately reacts with the variation of the air-fuel ratio. Hence, the deterioration of the upstream oxygen sensor can comparatively easily be detected by monitoring the output of the upstream air-fuel ratio sensor when the variation of the air-fuel ratio is brought about.

In contrast thereto, since the downstream oxygen sensor is provided downstream from the catalyst, the downstream oxygen sensor detects the air-fuel ratio in emission gas after passing the catalyst. Therefore, even when the variation of the air-fuel ratio is brought about, the variation of the air-fuel ratio is smoothed by oxygen adsorption and detachment by oxidation and reduction reaction of the catalyst or a storage effect of the catalyst and the downstream oxygen sensor detects the smoothed air-fuel ratio. Further, the storage effect of the catalyst is changed by the deterioration. Therefore, it is difficult to detect the deterioration of the downstream oxygen sensor per se from a state of reaction of the downstream oxygen sensor with respect to the variation of the air-fuel ratio of the engine.

In order to solve the problem, there has been proposed a method of detecting the deterioration of the downstream air-fuel ratio sensor which is difficult to be effected by influence of the catalyst. For example, in JP-U-03-037949, an output of an oxygen sensor downstream from a catalyst is detected with respect to a variation in an air-fuel ratio upstream from the catalyst before the catalyst is activated. Further, in JP-A-62-250351, a deterioration is detected when an air-fuel ratio is changed more than a catalyst storage function as in fuel cut.

[Problem to be Solved]

However, according to the method of detecting the deterioration of the oxygen sensor before activating the catalyst as in JP-U-03-037949, a condition of capable of detecting the deterioration is limited to that in cold starting. Similarly, according to the method of detecting the deterioration of the oxygen sensor in fuel cut as in JP-A-62-250351, a condition of capable of detecting the deterioration is limited to that in fuel cut. Particularly, in the case of the vehicle of an automatic transmission, fuel cut is hardly operated in running a city area and therefore, a frequency of executing deterioration detection is reduced.

In this way, in either of the methods, the executing condition is significantly limited and therefore, the detection frequency is reduced. Further, even when the executing condition is established, the executing condition is under a transient condition and therefore, there poses a problem that it is difficult to ensure detection accuracy.

Therefore, it is an object of the invention to provide an apparatus of detecting a deterioration of an air-fuel ratio detecting apparatus which is difficult to be effected by an influence of a catalyst storage function and capable of ensuring a detection frequency.

[Solution]

In order to achieve the above-described object, according to the invention of claim 1, a deterioration of an air-fuel ratio detecting means is detected by comparing outputs of the air-fuel ratio detecting means when a temperature of a solid electrolyte element is adjusted at least to two different temperatures by temperature adjusting means.

Abnormality of the air-fuel ratio detecting means is detected by utilizing a characteristic that when the temperature of the solid electrolyte element of the air-fuel ratio detecting means is changed, a sensitivity with respect to an emission gas component is changed by a difference in the temperature of the solid electrolyte element, that is, the activity of an electrode portion thereof.

For example, in the case of a normal air-fuel ratio detecting means, in accordance with a change of the temperature of the element, the sensitivity with respect to emission gas is changed and therefore, when output waveforms are compared between different element temperatures, a difference is produced. In contrast thereto, in the case of a deteriorated air-fuel ratio detecting means, the electrode portion is deteriorated, the activity is reduced and therefore, even when the element temperature of the solid electrolyte is changed, the change of the output waveform is reduced. Therefore, the deterioration of the air-fuel ratio detecting means can be detected by comparing outputs of the air-fuel ratio detecting means at different temperatures of the solid electrolyte element.

Here, the air-fuel ratio sensor may be provided with the above-described characteristic and includes a linear air-fuel ratio sensor or an oxygen sensor. Further, although the invention of claim 1 is particularly effective in an air-fuel ratio detecting means provided downstream from a catalyst, the invention can also be used in an air-fuel ratio detecting means provided upstream from the catalyst.

The detection accuracy can be improved by comparing the outputs of the air-fuel ratio detecting means in a same operating condition.

As a method of comparing the outputs of the air-fuel ratio detecting means, as defined in claim 3, it is preferred to compare the outputs of the air-fuel ratio detecting means relative to predetermined variations of the air-fuel ratio. Further, as defined in claim 4, it is preferred to compare a response of the air-fuel ratio detecting means relative to predetermined variations of the air-fuel ratio or a parameter related to an output characteristic with respect to the emission gas. Still further, as defined in claim 5, it is preferred to use, as the response or the parameter related to the output characteristic with respect to the emission gas, at least one of an output variation width, an output integrated value, an output differential value, an integrated value of the output differential value, an output period and an output frequency of the air-fuel ratio detecting means.

As such, deterioration detection accuracy can be improved by comparing the outputs of the air-fuel ratio detecting means.

As the temperature adjusting means, as defined in Claim 6, it is preferred to estimate the temperature of the solid electrolyte element by detecting an internal resistance of the air-fuel ratio detecting means and adjust the temperature of the solid electrolyte element based on the estimated temperature.

As such, since the temperature adjustment for the solid electrolyte in case of deterioration detection is performed accurately, the deterioration detection accuracy can be improved.

Further, as the temperature adjusting means, as defined in Claim 7, it is preferred to determine a heat amount for adjusting the temperature of the solid electrolyte element in accordance with an operating condition. As such, the accuracy of temperature adjustment for the solid electrolyte can be improved.

In this case, as defined in Claim 8, it is preferred to supply or stops the heat amount for adjusting the temperature of the solid electrolyte element under a predetermined operating condition.

Further, as defined in Claim 10, it is preferred to provide a temperature adjusting failure detecting means for detecting a failure of the temperature adjusting means, and detect the deterioration of the air-fuel ratio detecting means only when the failure is not detected by the temperature adjusting failure detecting means.

As such, the air-fuel ratio sensor can be prevented from being erroneously detected as being deteriorated in spite of no deterioration, when the temperature adjusting means is in failure.

[Detailed Description of the Invention]

First Embodiment

A first embodiment of the invention will be explained in reference to Fig. 1 through Fig. 17 as follows.

An embodiment embodying the invention in an air-fuel ratio detecting apparatus will be explained in reference to the drawings as follows. Further, the air-fuel ratio detecting apparatus according to the embodiment is particularly applied to an electronic control gasoline injection engine mounted to an automobile. In an air-fuel ratio control system of the engine, a fuel injection amount to the engine is controlled to a desired air-fuel ratio based on a detection result by the air-fuel ratio detecting apparatus.

First, an outline constitution of a total of an engine control system will be explained in reference to Fig. 1. At the most upstream portion of an intake pipe 12 of an engine (internal combustion engine) 11, an air cleaner 13 is provided and on a downstream side of the air cleaner 13, an air flow meter 14 for detecting an intake air amount is provided. On a downstream side of the air flow meter 14, a throttle valve 15 and a throttle opening degree sensor 16 for detecting a throttle opening degree are provided.

Further, on a downstream side of the throttle valve 15, a surge tank 17 is provided and at the surge tank 17, an intake pipe pressure sensor 18 for detecting an intake pipe pressure is provided. Further, at the surge tank 17, an intake manifold 19 for introducing air to respective cylinders of the engine 11 is provided and at a vicinity of an intake port of the intake manifold 19 of each cylinder, a fuel injection valve 20 for injecting fuel is attached.

Meanwhile, at a middle of an exhaust pipe 21 (emission gas path) of the engine 11, an upstream side catalyst 22 and a downstream side catalyst 23 for reducing harmful components (CO, HC, NOx or the like) in emission bas are installed in series. In this case, the upstream side catalyst 22 is formed in a comparatively small capacity such that warming up is finished at early time in starting and exhaust emission in starting is reduced. In contrast thereto, the downstream side catalyst 23 is formed in a comparatively large capacity such that emission gas can sufficiently be cleaned even in a high load region increasing an amount of emission gas.

Further, on an upstream side of the upstream side catalyst 22, a linear air-fuel ratio sensor 24 for outputting a linear air-fuel ratio signal in accordance with an air-fuel ratio of emission gas is provided and on a downstream side of the upstream side catalyst 22 and on a downstream side of the downstream side catalyst 23, there are provided a first oxygen sensor 25 and a second oxygen sensor 26 having a so-called Z characteristic in which outputs thereof are respectively changed comparatively rapidly at a vicinity of a theoretical air-fuel ratio. Hereinafter, a combination of the linear air-fuel ratio sensor and the oxygen sensors is described as an air-fuel ratio sensor. Further, at a cylinder block of the engine 11, a cooling water temperature sensor 27 for detecting cooling water temperature and a crank angle sensor 28 for detecting an engine rotational number NE are attached.

Outputs of the various sensors are inputted to an engine control circuit (hereinafter, referred to as "ECU") 29. The ECU 29 is mainly constituted by a microcomputer and controls, for example, an air-fuel ratio of emission gas by a feedback control by executing a program stored to ROM (storage medium) included therein.

According to the embodiment, the air-fuel ratio of emission gas is controlled by a feedback control described in, for example, JP-A-2001-193521.

Fig. 2 is a flowchart of an air-fuel ratio feedback control when in the constitution of Fig. 1, the linear air-fuel ratio sensor 24 is used as an air-fuel ratio sensor on the upstream side of the catalyst and either one of the first oxygen sensor 25 and the second oxygen sensor 26 is switched to use as an air-fuel ratio sensor on the downstream side of the catalyst.

Further, Fig. 3 and Fig. 4 are flowcharts of other air-fuel ratio feedback control when the second oxygen sensor 26 is used in addition to the linear air-fuel ratio sensor 24 and the first oxygen sensor 25 of Fig. 1.

First, a processing content of a target air-fuel ratio setting program of Fig. 2 will be explained. When the program is started, at step 701, the oxygen sensor on the downstream side used for setting a target air-fuel ratio λTG is selected form the first oxygen sensor 25 and the second oxygen sensor 26.

For example, in low load operation having a small flow rate of emission gas, emission gas can considerably be cleaned only by the upstream side catalyst 22. Therefore, response of the air-fuel ratio control is excellent when the first oxygen sensor 25 is used as the sensor on the downstream side used for setting the target air-fuel ratio λTG. However, when the emission gas flow rate is increased, an emission gas component amount passing through the upstream side catalyst 22 without being cleaned at inside thereof is increased and therefore, it is necessary to clean emission gas by effectively using both of the upstream side catalyst 22 and the downstream side catalyst 23. In this case, it is preferable to carry out the air-fuel ratio feedback control also in consideration of the state of the downstream side catalyst 23 and therefore, it is preferable to use the second oxygen sensor 26 as the sensor on the downstream side used for setting the target air-fuel ratio λTG.

Further, the shorter the delay time by which a change in the air-fuel ratio of emission gas emitted from the engine 11 (a change in an output of the air-fuel ratio sensor 24 on the upstream side of the upstream side catalyst 22) emerges as a change in an output of the first oxygen sensor 25, it signifies, the larger the emission gas component amount passing through the upstream side catalyst 22 without being cleaned at inside thereof (that is, a cleaning efficiency is reduced). Therefore, when the delay time of the change in the output of the first oxygen sensor 25 is short, it is preferable to use the output of the second oxygen sensor 26 as the sensor on the downstream side used in setting the target air-fuel ratio λTG.

Hence, a condition of selecting the second oxygen sensor 26 as the sensor on the downstream side used in setting the target air-fuel ratio λTG is <1> the delay time (or period) by which the change in the air-fuel ratio of emission gas emitted from the engine 11 (the change in the output of the linear air-fuel ration sensor

24) emerges as the change in the output of the first oxygen sensor 25 is shorter than a predetermined time period (or a predetermined period), or <2> the intake air amount (emission gas flow rate) is equal to or larger than a predetermined value.

When either one of the two conditions <1> and <2> is satisfied, the second oxygen sensor 26 is selected and when both of the conditions are not satisfied, the first oxygen sensor 25 is selected. Further, the second oxygen sensor 26 may be selected when both of conditions <1> and <2> are satisfied.

After selecting the sensor on the downstream side used for setting the target air-fuel ratio λTG in this way, the operation proceeds to step 702 and determines rich or lean by whether output voltage VOX2 of the selected oxygen sensor is higher or lower than target output voltage (for example, 0.45V) in correspondence with the theoretical air-fuel ratio (λ=1). Here, in the case of lean, the operation proceeds to step 703 and determines whether the air-fuel ratio is lean also at preceding time. When the air-fuel ratio is lean both in preceding time and current time, the operation proceeds to step 704 and calculates a rich integration amount λIR from a map in accordance with a current intake air amount QA.

As maps of the rich integration amount λIR, there are stored a map for the upstream side catalyst downstream side sensor (first oxygen sensor) shown at an upper column of Fig. 5(a) and a map for the downstream side catalyst downstream side sensor (second oxygen sensor) shown at an upper column of Fig. 5(b) and either one of the maps is selected in accordance with the sensor used. A map characteristic of the rich integration amount λIR is set such that the larger the intake air amount QA, the smaller the rich integration amount λIR and at a region where the intake air amount QA is small, the rich integration amount λIR is set to be slightly larger in the map for the downstream side catalyst downstream side sensor than in the map for the upstream side catalyst downstream side sensor. After calculating the rich integration amount λIR, the operation proceeds to step 705, corrects the target air-fuel ratio λTG to a rich side by λIR, stores rich/lean at that time (step 713) and finishes the program.

Further, when the air-fuel ratio has been rich at preceding time and is inverted to lean at current time, the operation proceeds from step 703 to step 706 and calculates a skip amount λSKR to the rich side in accordance with the rich component storage amount OSTRich of the catalyst. Further, processings of calculating the rich component storage amount OSTRich are the same as processings described in JP-A-2001-193521 and an explanation thereof will be omitted here.

A map characteristic of Fig. 6 is set such that the smaller the absolute value of the rich component storage amount OSTRich, the smaller the rich skip amount λSKR. After calculating the skip amount λSKR, the operation proceeds to step 707, corrects the target air-fuel ratio λTG to the rich side by λIR+λSKR, stores rich/lean at that time (step 713) and finishes the program.

Meanwhile, at step 702, when the output voltage VOX2 of the oxygen sensor is rich, the operation proceeds to step 708 and determines whether the air-fuel ratio has been rich also at preceding time. When the air-fuel ratio is rich both at preceding time and current time, the operation proceeds to step 709 and calculates a lean integration amount λIL from the maps shown in Figs. 5(a) and 5(b) in accordance with the current intake air amount QA. As the maps of the lean integrating amount λIL, there are set a map for the upstream side catalyst downstream side sensor (first oxygen sensor) shown at a lower column of Fig. 5(a) and a map for the downstream side catalyst downstream side sensor (second oxygen sensor) shown at a lower column of Fig. 5(b) and either one of the maps is selected in accordance with a sensor selected as the sensor on the downstream side.

A map characteristic of the lean integration amount λIL of Fig. 5(a) and Fig. 5(b) is set such that the larger the intake air amount QA, the smaller the lean integration amount λIL and at a region where the intake air amount QA is small, the lean integration amount λIL is set to be slightly larger in the map for the downstream side catalyst downstream side sensor than in the map for the upstream side catalyst downstream side sensor. After calculating the lean integration amount λIL, the operation proceeds to step 710, corrects the target air-fuel ratio λTG to the lean side by λIL, stores rich/lean at that time (step 713) and finishes the program.

Further, when the air-fuel ratio has been on the lean side at preceding time and is inverted to the rich side at current time, the operation proceeds from step 708 to step 711 and calculates the skip amount λSKL to the lean side from the map shown in Fig. 6 in accordance with the lean component storage amount OSTLean of the catalyst. Further, processings of calculating the lean component storage amount OSTLean are the same as the processings described in JP-A-2001-193521 and an explanation thereof will be omitted here.

The map characteristic of Fig. 6 is set such that the smaller the lean component storage amount OSTLean, the smaller the lean skip amount λSKL. Thereafter at step 712, the operation corrects the target air-fuel ratio λTG by λIL+λSKL, stores rich/lean at that time (step 713) and finishes the program.

As is apparent from the map of Fig. 6, when the rich component storage amount OSTRich or the lean component storage amount OSTLean is reduced by the deterioration of the catalysts 22 and 23, the rich skip amount λSKR or the lean skip amount λSKL is gradually set to a small value and therefore, it can be prevented beforehand that the harmful component is emitted by carrying out excessive correction exceeding adsorption limits of the catalysts 22 and 23.

Next, other embodiment of processings of setting the target air-fuel ratio will be explained in reference to flowcharts of Fig. 3 and Fig. 4.

ECU 29 changes a target output voltage TGOX of the first oxygen sensor 25 in accordance with the output of the second oxygen sensor 26 when the first oxygen sensor 25 is selected as the sensor on the downstream side used in setting the target air fuel ratio λTG of the air-fuel ratio feedback control by executing a target air-fuel ratio setting program of Fig. 3 and a target output voltage setting program of Fig. 4.

Further, in Fig. 3, steps of executing processings similar to those of Fig. 2 are attached with step numbers the same as those of Fig. 2. In the following, a difference from of Fig. 2 will mainly be explained.

In the target air-fuel ratio setting program of Fig. 3, first, at step 701, the sensor on the downstream side used in setting the target air-fuel ratio λTG is selected from the oxygen sensor 25 on the downstream side of the upstream side catalyst 22 and the oxygen sensor 26 on the downstream side of the downstream side catalyst 23, and thereafter the operation proceeds to step 714 and sets the target output voltage TGOX of the sensor on the downstream side used for setting the target air-fuel ratio λTG by executing a target output voltage setting program of Fig. 4, mentioned later.

Thereafter, the operation proceeds to step 715, determines rich or lean by whether the output voltage VOX2 of the selected oxygen sensor is higher or lower than the target output voltage TGOX, calculates the target air-fuel ratio λTG by the above-described method at step 703 through 713 in accordance with a result of the determination, stores rich/lean at that time and finishes the program.

Next, a processing content of the target output voltage setting program of Fig. 4 executed at step 714 of Fig. 3 will be explained. When the program is started, first, at step 901, it is determined whether the first oxygen sensor 25 is selected as the sensor on the downstream side used for setting the target air-fuel ratio λTG. When the first oxygen sensor 25 is selected as the sensor on the downstream side used for setting the target air-fuel ratio λTG, the operation proceeds to step 902 and calculates the target output voltage TGOX in accordance with current output voltage of the second oxygen sensor 26 from a map of the target output voltage TGOX constituting a parameter by the output voltage of the second oxygen sensor 26.

In this case, the map of the target output voltage TGOX is set such that when the output voltage of the second oxygen sensor 26 (an air-fuel ratio of a gas flowing out from the downstream side catalyst 23) falls in a predetermined range ($\beta \leq$ output voltage $\leq \alpha$) at a vicinity of the theoretical air-fuel ratio, the target output voltage TGOX is reduced (becomes lean) as the output of the second oxygen sensor 26 is increased (becomes rich). Further, in a region in which the output of the second oxygen sensor 26 is larger than a predetermined value α, the target output voltage TGOX becomes a predetermined lower limit value (for example, 0.4V) and in a region in which the output of the second oxygen sensor 26 is smaller than a predetermined value β, the target output voltage TGOX becomes an upper limit value (for example, 0.65V).

Thereby, the target output voltage TGOX of the first oxygen sensor 25 is set to fall in a range in which an adsorption amount of an emission gas component of the downstream side catalyst 23 becomes equal to or smaller than a predetermined value or the air-fuel ratio of emission gas flowing in the downstream side catalyst 23 falls in a range of a predetermined cleaning window.

Meanwhile, when the second oxygen sensor 26 is selected as the sensor on the downstream side used for setting the target air-fuel ratio λTG, the operation proceeds from step 901 to step 903 and sets the target output voltage TGOX to a predetermined value (for example, 0.45V). The above-explained target output voltage setting program achieves a role in correspondence with second feedback controlling means.

Fig. 7 is a constitution view showing an outline of an air-fuel ratio detecting apparatus according to the embodiment. In Fig. 7, ECU 29 is provided with a microcomputer 120 constituting the center of internal operation thereof and the microcomputer 120 is connected to a host microcomputer 116 for realizing fuel injection control or ignition control communicatably to each other. The linear air-fuel ratio sensor 24 is attached to the exhaust pipe 21 extended from an engine main body of the engine 11 and an output thereof is detected by the microcomputer 120. The microcomputer 120 is constituted by well-known CPU, ROM, RAM, backup RAM and the like for executing various operation processings, not illustrated, for controlling a heater control circuit 125 and a bias control circuit

140 according to the prescribed controlling program.

Here, a bias instruction signal Vr is inputted to the bypass control circuit 140 via a D/A converter 121, a low pass filter (LPF) 122 and a switch 160. Further, the output of the linear air-fuel ratio sensor 24 in correspondence with the air-fuel ratio (oxygen concentration) from time to time is detected and a detected value thereof is inputted to the microcomputer 120 via an A/D converter 123. Further, heater voltage and heater current are detected by the heater control circuit 125, mentioned later, and a detected value thereof is inputted to the microcomputer 120 via an A/D converter 124.

Further, the predetermined bias instruction signal Vr is applied to an element, a change between predetermined time T1 and T2 shown in Figs. 8(a) and 8(b), that is, an element voltage change ΔV and an element current change ΔI are detected and an element impedance is detected by the following equation.

impedance = $\Delta V/\Delta I$

The detected element impedance value is inputted to the microcomputer 120. The element impedance is provided with a strong correlation with element temperature as shown by Fig. 9 and the element temperature of the air-fuel ratio sensor can be controlled by controlling a heater provided to the air-fuel ratio sensor by a duty control such that the element impedance becomes a predetermined value.

Further, similarly in the first oxygen sensor 25 and the second oxygen sensor 26, element temperature of the oxygen sensor can be controlled by detecting element impedance and controlling a heater provided to each of the first and the second oxygen sensor 25 and 26 by a duty control such that the element impedance becomes a predetermined value.

As a method therefor, according to the embodiment, as shown by Fig. 10, there is adopted a method of carrying out PI control (proportional, integral) by a deviation between actually detected element impedance and target impedance calculated from the target element temperature and the element temperature of the linear A/F sensor 24 (first oxygen sensor 25, second oxygen sensor 26) is controlled by the method.

Details thereof will be explained in reference to a flowchart of Fig. 10. In the flowchart, program processings are executed at predetermined timings (step 400).

First, at step 401, a deviation (Δimp) between the target impedance calculated from the target element temperature and the element impedance detected by the element impedance detecting circuit is calculated. At step 402, an integrated value of the impedance deviation ($\Sigma\Delta$imp) for carrying out integral control is calculated. At step 403, heater duty is calculated from an equation shown below by using the deviation, an integral value, a proportional coefficient P1 and an integral coefficient I2.

$$\text{heater duty (\%)} = P1\times\Delta imp+12\times\Sigma\Delta imp$$

The heater duty calculated here is inputted to the heater control circuit designated by numeral 125 of Fig. 7 and heater control of the linear air-fuel ratio sensor 24 (first oxygen sensor 25, second oxygen sensor 26) is carried out.

Here, the heater duty is a control amount of a heat generating amount for controlling temperature of the oxygen sensor element and based on power (W). In order to control temperature constant, it is preferable to control power constant and when temperature is controlled by the heater duty, in order to prevent temperature from changing by changing the supplied voltage, a correction relative to reference voltage (for example, 13.5V), that is, a correction by $\text{power}\times(13.5/\text{voltage})^2$ is carried out.

In Fig. 7, the linear air-fuel ratio sensor 24 is projected into the exhaust pipe 21 and the sensor 24 is constituted by a cover, a sensor main body and a heater by gross classification. The cover is formed in a channel-like shape in a section thereof and a number of small holes communicating inside and outside of the cover are formed at a peripheral wall thereof. The sensor main body as the sensor element portion generates a voltage in correspondence with an oxygen concentration in an air-fuel ratio lean region, or a concentration of uncombusted gas (CO, HC, H2 or the like) in an air-fuel ratio rich region.

The heater is contained at inside of an atmosphere side electrode layer for heating the sensor main body (atmosphere side electrode layer, solid electrolyte layer, emission gas side electrode layer) by heat generating energy thereof. The heater is provided with a heat generating capacity sufficient for activating the sensor main body.

Further, also constitutions of the first oxygen sensor 25and the second oxygen sensor 26 are similar to the above-described constitution.

Further, in recent years, there is proposed a laminated type air-fuel ratio sensor for constituting an element and heater by an integrated structure for promoting heater function, the proposal is applicable naturally to such a sensor and to any sensor so far as the sensor is the air-fuel ratio sensor arranged with an electrode at a solid electrolyte element regardless of a kind thereof.

Next, control operation of the proposal will be explained in reference to a system block diagram shown in Fig. 11. An embodiment in the case of applying the proposal to the first oxygen sensor 25 arranged directly below the upstream side catalyst of Fig. 1 will be described.

The first oxygen sensor (oxygen sensor) 25 detects an output by the emission gas component (rich gas and leans gas) emitted from the engine by an output detecting circuit 203 of ECU 29 and calculates an air-fuel ratio control amount by an air-fuel ration control calculating block 204. Here, an amount of increasing or reducing the fuel injection amount is determined by comparing target voltage, not illustrated, and detected voltage. The fuel injection amount determined as the air-fuel ratio control amount is supplied to the fuel injection valve 20 and a desired fuel injection amount is injected. An impedance calculating block 202 calculates the element impedance as has been explained in reference to Fig. 7 and Fig. 8, a heater control amount is determined by a deviation from the target impedance set by a target impedance setting block 213 by a heater control amount calculating block 214 and the heater is controlled such that the temperature of the sensor element of the first oxygen sensor 25 becomes desired temperature.

Here, the target impedance is calculated by the following procedure. An operating state is determined by an operating state determining block 210 by information from the crank angle sensor 28, the air flow meter 14, the throttle opening degree sensor 16 and the cooling water temperature sensor 27 showing the operating state of the engine.

Based on a result of determining the operating state, at a specific gas sensitivity priority determining block 211, it is determined whether a composition of emission gas emitted from the engine is mainly of rich gas or mainly of lean gas under a current operating condition or an operating state immediately thereafter. When it is determined that the composition is mainly of lean gas in a state in which NOx is liable to generate under high load or in accelerating by the specific gas sensitivity priority determining block 211, at a target element temperature setting block 212, the target element temperature is set to, for example, 720°C in order to elevate the element temperature of the oxygen sensor to promote lean gas reactivity.

Conversely, when it is determined that the composition is mainly of rich gas (or mainly constituted by rich gas) in a state in which HC, CO is liable to generate under low temperature, low load or in decelerating by the specific gas sensitivity priority determining block 211, at the target element temperature setting block 212, the target element temperature is set to, for example, 420°C in order to lower the element temperature of the oxygen sensor to promote rich gas reactivity.

Or, at a diagnosis execution determining block 215, it is determined whether an operating state in which deterioration detection (diagnosis) of the first oxygen sensor 25 or the second oxygen sensor 26 is to be executed is brought about based on a result of determining the operating state at the operating state determining block 210.

When it is determined that the operating state in which the diagnosis is to be executed is brought about, at the target element temperature setting block 212, the element temperature of the oxygen sensor is controlled to a low temperature state (for example, 400°C) for a predetermined period of time and thereafter the oxygen sensor element temperature is controlled to a high temperature state (for example, 700°C) for a predetermined period of time.

Here, the target element temperature setting block 212 determines the target element temperature by putting priority on a determination result of the diagnosis execution determining block 215 more than a determination result of the specific gas sensitivity priority determining block. That is, when it is determined at the diagnosis execution determining block 215 that the operating state in which the diagnosis is to be executed is brought about, the target element temperature is set to the temperature for executing the diagnosis. Further, when it is determined at the diagnosis execution determining block 215 that the operating state in which the diagnosis is to be executed is not brought about, the target element temperature is set based on the result determined by the specific gas sensitivity priority determining block 211.

Next, reactivities of rich and lean gases of the oxygen sensor will be explained in reference to characteristic diagrams of Fig. 12 and Fig. 13.

Fig. 12 shows a reactivity of an O_2 sensor with respect to carbon monoxide (CO) in nitrogen (N_2). As illustrated, it is shown that although at low element temperature, the sensor reacts with a small amount of CO, as the element temperature is elevated, reactivity with low concentration CO is reduced. This is because there is a temperature characteristic in the reactivity of CO of the O_2 sensor electrode and because at low temperature of the element, a reaction shown below is accelerated and O_2 is deprived.

CO (adsorbed) +1/2 O^{2-} (adsorbed) $\leftrightarrow$ CO_2+2e^-

Further, Fig. 13 shows a reactivity of the O_2 sensor when nitrogen monoxide (NO) is introduced into an atmosphere of nitrogen (N_2) and carbon monoxide (CO). As illustrated, although in a high temperature state of the element, the sensor reacts with a small amount of NO, as the element temperature is lowered, the sensor does not react with low concentration NO. This is because at a surface of an electrode of the O_2 sensor and at an electrode, a reaction shown below is carried out and at a high temperature region, in comparison with a low temperature region, combustion with rich gas (CO) and decomposition of NO of the electrode is further accelerated and therefore, electromotive force is reduced on the low concentration side.

$CO + NO \rightarrow CO_2 + N_2$

$2NO + 4e \rightarrow N_2 + 2O^{2-}$

Based on the target temperature set by the target element temperature setting block 212 of Fig. 11, at the target impedance setting block 213, the target impedance is set from the relationship between the element impedance and the element temperature shown in Fig. 9. Further, the heater control amount is determined by comparing with the above-described detected value of the element impedance at the heater control amount calculating block 214.

Next, diagnosis processings of the first oxygen sensor 25 will be explained in reference to a flowchart of Fig. 14. Further, although similar diagnosis processings are executed also with respect to the second oxygen sensor 26, an explanation thereof will be omitted here.

The routine is started at a predetermined timing of time or a number of times of injection (step 500). First, at step 501, a condition of executing diagnosis is determined based on whether an engine rotational speed or an intake air amount falls in a predetermined range, or whether catalyst temperature is equal to or lower than predetermined temperature. Here, it is preferable that the condition of executing diagnosis is a stable steady-state running state in order to promote accuracy of deterioration detection.

When it is determined that the condition of executing diagnosis is established at step 501, at step 502, low element temperature control is started by setting a target element impedance to 2000Ω such that element temperature of the first oxygen sensor 25 (b)ecomes low (for example, 400°C).

At step 503, it is determined whether the element impedance falls in a predetermined range in order to detect whether the element temperature is desired temperature. Here, processings at step 502 and at step 503 are repeated until the impedance falls in a predetermined range and when the impedance falls in the predetermined range, the operation proceeds to step 504.

At step 504, an output voltage change speed of the first oxygen sensor 25 is calculated by calculating a change amount ΔV between predetermined timings of the output voltage of the first oxygen sensor 25 in the low element temperature state.

$$\Delta V1=|V1n-V1n-1|$$

Here, notation V1n designates a current value of the first oxygen sensor 25 and notation V1n-1 is a preceding value of the output of the first oxygen sensor 25.

Further, although according to the embodiment, the change speed is calculated without differentiating a rich direction of the O_2 sensor (change speed is a positive value) and a lean direction thereof (change speed is a negative value), the change speed may be calculated only in a specific direction of rich or lean.

At successive step 505, in order to promote accuracy of deterioration detection, a change speed integrated value (sdloxs1) is calculated based on the following equation by summing up the change speed for a predetermined time period.

$$sdloxs1=\Delta V1n-1+\Delta V1n$$

Here, notation ΔV1n designates a current value of the change amount ΔV1 and the notation ΔV1n-1 designates a preceding value of the change amount ΔV1.

Next, at step 506, it is determined whether a predetermined time period T3 has elapsed. Here, processings of from step 504 to step 506 are repeated until it is determined that the predetermined time period has elapsed. When it is determined that the predetermined time period has elapsed at step 506, the operation proceeds to step 507.

At step 507, the element temperature control is switched to high element temperature control. According to the embodiment, the target impedance is set to 25Ω such that the element is at high temperature (for example, 700°C).

At successive step 508, it is determined whether the element impedance falls in a predetermined range ($15\Omega \leq$ element impedance $\leq 25\Omega$). Here, processings at step 507 and at step 508 are repeated until it is determined that the element impedance falls in the predetermined range. When it is determined that the element impedance falls in the predetermined range at step 508, similar to the processings at low temperature, at step 509, an oxygen sensor voltage change speed at high temperature ΔVh ($=|Vhn-Vhn-1|$) is calculated and at step 510, the O_2 sensor voltage change speed integrated value sdloxsh ($=\Delta Vhn-1+\Delta Vn$) is calculated.

Next, it is determined whether a predetermined time period T5 has elapsed at step 511. Here, when the predetermined time period has not elapsed, processings of from step 509 to step 511 are repeated until the predetermined time period has elapsed. When the predetermined time period has elapsed, the operation proceeds to step 512.

At step 512, a deviation amount (delxhl) between the change speed integrated value sdloxsl at low temperature and the change speed integrated value sdloxsh at high temperature is calculated by the following equation.

deloxhl=sdloxsl-sdloxsh

Next at step 513, the change speed integrated value deviation amount delxhl and a previously set predetermined value are compared. Here, when the change speed integrated value deviation amount delxhl is smaller than the previously set predetermined value, the operation proceeds to step 514 and determines that the first oxygen sensor is deteriorated. Further, when the change speed integrated value deviation amount delxhl is larger than the previously set predetermined value, the operation proceeds to step 515 and determines that the first oxygen sensor is normal.

Next, operation of the embodiment will be explained in reference to time charts of Figs. 15(a) through 15(i).

Here, Fig. 15(a) shows whether the condition of executing the diagnosis processings is established. Further, Fig. 15(b) shows whether the element temperature control is requested at normal control time when the diagnosis processing are not executed, or low element temperature control time or high element temperature control time when the diagnosis processings are executed. Further, Fig. 15(c) shows the element temperature of the solid electrolyte. Fig. 15(d) shows the output of the first oxygen sensor when the sensor is deteriorated and Fig. 15(e) shows the output of the first oxygen sensor when the sensor is normal. Fig. 15(f) shows the change speed integrated value sdloxsl at low element temperature control time and Fig. 15(g) shows the change speed integrated value sdloxsh at high element temperature control time. Fig. 15(h) shows the change speed integrated value deviation amount delxhl. Further, Fig. 15(i) shows an abnormality detection flag.

In Figs. 15(a) through 15(i), at time T1 at which the condition of executing the diagnosis processings is established, low element temperature control (low temperature control) of the element temperature of the first oxygen sensor is requested and the target impedance, not illustrated, is set to be large (for example, 2000Ω). Thereby, the heater is controlled such that the element temperature of the solid electrolyte becomes 400°C.

Next, at and after time T2 at which the element temperature of the solid electrolyte is stabilized at low temperature (the element impedance falls in the predetermined range (1800Ω ≤ element impedance ≤ 2200Ω)), the output of the voltage of the normal oxygen sensor is varied by a large amount since the reactivity by rich gas (CO) is increased. In contrast thereto, the variation amount of the output of the deteriorated oxygen sensor is small since the reactivity is reduced. The change speed is calculated by calculating the output variation amount of the oxygen sensor at that time at every predetermined timing. The change speed calculated in this way is summed up until reaching time T3 and the integrated value of the change speed sdloxsl at low temperature control is calculated.

Successively, when time T3 is reached, at this time, the high element temperature control (high temperature control) of the element temperature of the first oxygen sensor is requested and the target impedance is set to be small (for example, 25Ω). Thereby, the heater is controlled such that the element temperature of the solid electrolyte becomes 700°C.

At and after time T4 at which the solid electrolyte element is stabilized at high temperature (the element impedance falls in the predetermined range (15Ω ≤ element impedance ≤ 25Ω)), the variation amount of the output voltage of the normal oxygen sensor is reduced since the reactivity by rich gas (CO) is reduced in comparison with that at low temperature control. Further, the variation amount of the deteriorated sensor is similarly reduced.

During a time period until reaching time T5, the change speed integrated value sdloxsh in high temperature control is calculated similar to that in low temperature control.

Further, at a time point of time T5, the change speed integrated value deviation amount delxhl which is the deviation between the change speed integrated value sdloxsl at low temperature control time and the change speed integrated value sdloxsh at high temperature control time is calculated. The deviation amount delxhl becomes a large value when the oxygen sensor is normal and becomes a small value when the oxygen sensor is deteriorated by the above-described reason and therefore, presence or absence of the deterioration can be determined by comparing with a predetermined determinant. Further, although according to the embodiment, it is determined whether the oxygen sensor is deteriorated or normal, a degree of the deterioration can also be detected by providing a plurality of determinants. Naturally, the deviation amount delxhl can also be used as an index of the degree of deterioration as it is.

Further, although according to the embodiment, an explanation has been given of deterioration detection of the first oxygen sensor 25, the embodiment is not limited thereto but can also be used for deterioration detection of the second oxygen sensor 26. Further, the embodiment can also be used for the linear air-fuel ratio sensor 24.

Next, an explanation will be given of the fact that the diagnosis processings according to the embodiment are difficult to be effected by influence by the catalyst storage function in reference to Fig. 16 and Fig. 17.

As shown by Fig. 16, the lower the element speed, the larger the change speed of the oxygen sensor since the lower the element temperature, the more increased is the sensitivity of the rich gas (CO) component. Therefore, a degree of deterioration of the oxygen sensor can be detected by the deviation between the change speeds when the element temperature is high (for example, 700°C) and when the element temperature is low (for example, 400°C).

Further, in a state in which the catalyst is deteriorated and particularly the O_2 storage function is reduced, the change speed of the oxygen sensor output is increased as shown by Fig. 16 in comparison with that when the catalyst is normal. However, according to the method, the deviation between the change speeds when the element is controlled to high temperature and when the element is controlled to low temperature and the deterioration of the oxygen sensor is determined based on the deviation and therefore, a change amount by the catalyst storage is canceled and the influence is difficult to be effected.

Fig. 17 shows the deviation of the O_2 sensor change speed in accordance with the degree of deteriorating the catalyst. In this way, according to the invention, the influence of the catalyst storage function is difficult to be effected and therefore, the normal oxygen sensor and the deteriorated oxygen sensor can be differentiated from each other without depending on the cleaning function or the degree of deterioration of the catalyst.

Second Embodiment

A second embodiment of the invention will be explained in reference to Fig. 18 through Fig. 25 as follows.

In the first embodiment, a description has been given of the method of detecting abnormality of the O_2 sensor by comparing the variations of the sensor outputs when the element temperature of the O_2 sensor is controlled to high temperature and when the element temperature is control to low temperature under a certain specific operating condition. According to the second embodiment, a method of further promoting detection performance will be explained.

Fig. 18 shows an outline flowchart. First, at a predetermined timing, step 1000 is started. Next, at step 1001, there is determined the condition of executing diagnosis of whether the rotational speed or the air amount of the engine is under the predetermined operating condition and/or whether the catalyst temperature is equal to or higher than the predetermined temperature. Further, it is determined also as the condition of executing diagnosis whether the sensor element temperature is stabilized by an elapse time period after executing the temperature control of the sensor element, not illustrated, or an estimated value of the sensor element temperature (including element impedance).

At step 1001, when it is determined that the condition of executing diagnosis is not established, the operation proceeds to step 1008 and finishes the program. When it is determined that the condition of executing diagnosis is established at step 1001, the operation proceeds to 1002.

At step 1002, it is determined whether the low element temperature control is to be executed. When it is determined that the low element temperature control is to be executed here, the operation proceeds to step 1003 in order to further promote detection performance of diagnosis, makes a proportional control gain (rich side proportional gain) of sub feedback control by the first oxygen sensor 25 larger than that in normal control to thereby provide larger gas change. According to the embodiment, the gain is changed from 0.1 at normal time to 0.2.

At sensor low element temperature control time, the reactivity with rich gas (CO) of the oxygen sensor is promoted and therefore, by increasing the control gain in this way, larger correction can be achieved. Therefore, when the sensor detects rich (large output), by carrying out large reducing correction, lean gas can be supplied at once and the oxygen sensor reacts with rich/lean significantly. Further, the operation proceeds to step 1004 and the variation of the sensor output is summed up.

Further, at step 1002, when it is determined that the low element temperature control is not executed, the operation proceeds to step 1005 at step 1005, it is determined whether high element temperature control is to be executed. In the case of the high element temperature control, the operation proceeds to 1006 and makes a proportional control gain (lean side proportional gain) of the sub feedback control larger than that at normal time similar to step 1003. According to the embodiment, the gain is changed from 0.05 at normal time to 0.1. Further, at step 1007, the variation of the sensor output is summed up.

According to the embodiment, in accordance with the sensor high element temperature control, the proportional gain on the rich side or the lean side is significantly changed to more remarkably extract respective gas reaction characteristics. However, it is not necessarily needed to change the respective gains in order to promote detection performance but in executing diagnosis, the proportional gain of the sub feedback control may be increased without depending on the temperature control. Further, the proportional gain of the sub feedback control may be changed such that only the reactivity on the rich side or the reactivity on the lean side is utilized.

Next, abnormality determination of the first oxygen sensor 25 will be explained in reference to Fig. 19. Further, although an explanation is given here only of the first oxygen sensor 25, the abnormality determination is similarly applicable to the second oxygen sensor 26.

First, when step 1100 is started at a predetermined timing, at successive step 1101, a determination of whether normal/abnormal of the first oxygen sensor 25 may be determined is executed. This is determined based on whether the sensor output variation integration shown in Fig. 18 is executed for the predetermined time period and when respectives of the sensor high element temperature control and the low element temperature control are executed.

When it is determined that the condition of determining diagnosis is established, the operation proceeds to step 1102. At step 1102, there is calculated a ratio pdloxs (=sdloxsl/sdloxsh) of the sensor output variation integration (sdloxsh) at high element temperature control time to the sensor output valuation integration (sdloxsl) at sensor low element temperature control time. Thereby, the deterioration of the sensor can stably be determined by excluding ageing change of catalyst deterioration or the like.

Next, the operation proceeds to step 1103 and determines whether the sensor output variation integration ratio pdloxs is equal to or smaller than a predetermined value. Here, when the ratio is equal to or smaller than the predetermined value, it is determined that the reactivities of the sensor electrode when the sensor element is at low temperature and at high temperature are deteriorated and the operation proceeds to 1104. Further, at step 1104, a first oxygen sensor abnormality flag is erected. Meanwhile, when it is determined that the sensor output variation integration ratio pdloxs is larger than the predetermined value at step 1103, the operation proceeds to step 1105. Further, a first oxygen sensor normality flag is erected.

Although in Fig. 18, the proportional gain of the sub feedback control is changed at the stoichiometric value (0.45V) of the oxygen sensor or higher or the value or lower, according to a modified example of Fig. 20, the proportional gain is changed at a value weakly richer than the stoichiometric value (0.55V) or higher or a value weakly leaner than the stoichiometric value (0.35V) or lower. Thereby, the normality determination in the case of reacting with richer or leaner than normal can easily be executed and abnormality can be prevented from being determined erroneously. An explanation will be given of portions thereof changed those in from Fig. 18 as follows.

According to the modified example, at step 1002 of Fig. 20, when it is determined that the low element temperature control is being executed, the operation proceeds to step 1020 and determines whether the first oxygen sensor output is larger than 0.55V. When it is determined that the output is larger than 0.55V, the operation proceeds to step 1003 and carries out a processing similar to that of Fig. 18. Meanwhile, at step 1020, when it is determined that the first oxygen sensor output is equal to or smaller than 0.55V, the operation proceeds to step 1021, sets the rich proportional gain to 0.1 and the lean proportional gain to 0.05 and proceeds to step 1004.

Also when it is determined that the high element temperature control is being executed at step 1005, similarly, at successive step 1022, at this time, it is determined whether the first oxygen sensor output is less than 0.35V. When it is determined here that the output is less than 0.35V, the operation proceeds to step 1006 and executes a processing similar to that in Fig. 18. Meanwhile, when the first oxygen sensor output is equal to or larger than 0.35V, the operation proceeds to step 1023 and sets the rich proportional gain to 0.1 and the lean proportional gain to 0.05.

Next, operation of the second embodiment will be explained in reference to time charts of Figs. 21(a) through Figs. 21(k).

In Figs. 21(a) through 21(k), Fig. 21(a) shows a vehicle speed. Fig. 21(b) shows diagnosis executing condition. Fig. 21(c) shows a request of the element temperature control and Fig. 21(d) shows the element temperature. Further, Fig. 21(e) shows a request of the proportional gain of the sub feedback. Fig. 21(f) shows the first oxygen sensor output when deteriorated and Fig. 21(g) shows the first oxygen sensor output at normal time. Further, Fig. 21(h) shows the output integrated value sdloxsl at low element temperature control time, Fig. 21(i) shows the output integrated value sdloxsh at high element temperature control time and Fig. 21(j) shows the output integration ratio pdloxs. Further, Fig. 21(k) shows the abnormality detection flag.

In Figs. 21(a) through 21(k), at time T1 at which accelerating running is shifted to steady-state running, the diagnosis executing condition is established and the diagnosis execution allowance flag is made ON. At this time, the sensor low element temperature control is requested and the sensor element temperature of the first oxygen sensor is made to be low by setting the target impedance, not illustrated, to be large. As a result, the element temperature is lowered to 400°C.

Next, at time T2 at which the element temperature is stabilized, the proportional gain of the sub feedback control is set to be large and therefore, a request for the sub feedback gain requests high gain. At this time, the output of the oxygen sensor is increased since the oxygen sensor is reacted by rich gas (CO) and since the proportional gain is large, correction to the lean side (reducing correction of injection amount) is significantly operated and the oxygen sensor output is operated significantly to the lean side.

Here, when the electrode of the oxygen sensor is deteriorated, the reactivity is reduced and therefore, the illustrated output of the oxygen sensor when deteriorated is brought about, however, when the oxygen sensor is normal, the output is further significantly varied as in the illustrated output of the oxygen sensor at normal time. The variation of the output of the oxygen sensor at this time is summed up and the low temperature time output integrated value is calculated. In this way, the output of the O_2 sensor when the element is at low temperature is finished to be integrated during a predetermined time period between time T2 to T3 and the sensor high element temperature control is successively executed.

However, at time T4, the diagnosis executing condition is not established and therefore, the sensor high element temperature control is returned to the normal temperature control. Thereafter, when the diagnosis executing condition is established again at time T5, the high element temperature control is started and at time T6 at which the sensor element temperature is stabilized to be high, a request for increasing the sub feedback gain is issued and the proportional gain is set to be large.

Further, during a predetermined time period from time T6 to T7, the integrated value of the oxygen sensor output variation at the sensor element high temperature time is calculated. At time T7, the integrated values of the output variations of the oxygen sensor when the sensor element is at low temperature and when the sensor element is at high temperature have respectively been calculated and therefore, the ratio of the integrated values of the output variation of the oxygen sensor when the sensor element is at low temperature and when the sensor is at high temperature is calculated.

When the sensor electrode is normal, the output variation integrated value ratio becomes larger than a predetermined value, however, when the electrode is deteriorated, the output variation integrated value ratio becomes small. By comparing the output variation integrated value ratio with a previously stored determinant in this way, the deterioration of the sensor electrode can be detected.

Although according to the above-described method, the diagnosis detection is carried out by utilizing the sub feedback control for correcting the feedback control of the air-fuel ratio by the air-fuel ratio sensor before the catalyst (hereinafter, described as main feedback control), a method of utilizing the main feedback control will be explained in reference to Fig. 22 as a modified example.

In Fig. 22, although the determination of the sensor element temperature control at step 1002 and step 1005 are similar to those shown in Fig. 18, instead of increasing the proportional gain of the sub feedback control, the target air-fuel ratio of the main feedback control is changed. That is, at steps 1030 and 1031, the target air-fuel ratio of the main feedback control is set to be weakly rich (14.5) and at steps 1032 and 1033, the target air-fuel ratio of the main feedback control is conversely set to be weakly lean (14.7).

When the sensor element temperature is controlled to be low in this way, the reactivity is promoted by rich gas (CO) and therefore, an effect is achieved by controlling emission gas on the rich side. In contrast thereto, when the sensor element temperature is controlled to be high, the effect is promoted by controlling emission gas in the lean side.

Here, the air-fuel ratio after the catalyst is set to be weakly rich at step 1031, further, the air-fuel ratio after the catalyst is set to be weakly lean at step 1033 and diagnosis is executed by detecting the variation of the O_2 sensor by the sub feedback control.

However, a similar effect can be achieved even when the sub feedback control is stopped and a variation of the air-fuel ratio by a small amount is provided to the main feedback control at every predetermined time period.

As shown by Fig. 23, integration of the sensor output variation is significantly influenced by the variation of the air-fuel ratio before the catalyst. Although as described above, when the diagnosis is executed only in the stabilized operating state, the influence of the variation of the air-fuel ratio before the catalyst is not effected, in order to increase the detection frequency, the influence needs to be excluded.

The embodiment will be explained in reference to Fig. 24. A basic constitution thereof is the same as that in Fig. 19 and therefore, an explanation will be given by centering on a difference therebetween. When it is determined at step 1101 that the diagnosis determining condition is established, at step 1120, a ratio of integration of the variation of the air-fuel ratio before the catalyst to integration of a variation of the air-fuel ratio after the catalyst (oxygen sensor output variation) is calculated respectively when the sensor element is controlled at low temperature and when the sensor element is controlled at high temperature. Thereby, the influence of the variation of the air-fuel ratio before the catalyst is excluded.

At successive step 1121, there is calculated a ratio pdloxs (=kdloxsl/kdloxsh) of a ratio kdloxsl of and integrated value of the variation of the air-fuel ratio before the catalyst to an integrated value of the variation of the air-fuel ratio after the catalyst which are calculated at step 1120 when the sensor element has low temperature, to a ratio kdloxsh of the integrated value of the variation of the air-fuel ratio before the catalyst to the integrated value of the variation of the air-fuel ratio after the catalyst when the sensor element is at high temperature. Next, the operation proceeds to step 1103, and determines whether the first oxygen sensor is normal or abnormal as has been explained in reference to Fig. 19.

Although according to the invention, an explanation has been given of executing diagnosis by using the integrated value of the output variation of the oxygen sensor, the diagnosis can also be executed by change speed (ΔV) per time, an amplitude, or a frequency of the O_2 sensor. However, as shown by Fig. 25, there is a characteristic in which when an air amount is increased, a reaction rate of the O_2 sensor is increased and the change speed needs to correct in accordance with the air amount.

[Brief Description of the Drawings]

Fig. 1 is an outline constitution view of an embodiment of the invention;

Fig. 2 is a flowchart of processings of setting a target air-fuel ratio according to a first embodiment;

Fig. 3 is a flowchart of processings of setting a target air-fuel ratio in a modified example according to the first embodiment;

Fig. 4 is a flowchart of processings of setting a target output voltage of a first oxygen sensor of the modified example according to the first embodiment;

Fig. 5 show maps for setting a rich integration amount and a lean integration amount according to the first embodiment;

Fig. 6 is a map for setting a skip amount of the first embodiment;

Fig. 7 is an outline constitution view of an apparatus of detecting an air-fuel ratio and an impedance according to the first embodiment;

Fig. 8 show times chart in detecting the impedance;

Fig. 9 is an impedance characteristic diagram of an oxygen sensor;

Fig. 10 is a flowchart of controlling a heater of the oxygen sensor of the first embodiment;

Fig. 11 is a block diagram of controlling an element temperature of the oxygen sensor;

Fig. 12 is a CO reaction characteristic diagram of the oxygen sensor;

Fig. 13 is an NO reaction characteristic diagram of the oxygen sensor;

Fig. 14 is a flowchart of processings of detecting a deterioration of the oxygen sensor;

Figs. 15(a) through 15I are time charts showing operation in detecting the deterioration of the oxygen sensor;

Fig. 16 is a characteristic diagram showing principle of detecting the deterioration of the oxygen sensor;

Fig. 17 is a characteristic diagram showing an allowance of detecting the deterioration of the oxygen sensor;

Fig. 18 is a flowchart executed by ECU of a second embodiment;

Fig. 19 is a flowchart showing processings of detecting a deterioration of an oxygen sensor according to the second embodiment;

Fig. 20 is a flowchart executed by ECU of a modified example of the second embodiment;

Figs. 21A through 21K are time charts showing operation of the second embodiment;

Fig. 22 is a flowchart executed by ECU of a modified example of the second embodiment;

Fig. 23 is a correlation diagram showing a relationship between a variation in an air-fuel ratio before a catalyst and a summed value of a variation in a sensor output;

Fig. 24 is a flowchart executed by ECU of a modified example of the second embodiment; and

Fig. 25 is a correlation diagram showing a relationship between an intake air amount and a sensor output variation.

[Explanation of Numerals]

11 … engine, 14 … air flow meter, 16 … throttle opening degree sensor, 18 … intake pipe pressure sensor, 22 … upstream catalyst, 23 … downstream catalyst, 24 … linear air-flow ratio sensor (limit current type air-fuel ratio sensor), 25 … first oxygen sensor (oxygen sensor), 26 … second oxygen sensor (oxygen sensor), 27 … coolant temperature sensor, 28 … crank angle sensor, 29 … engine control circuit (ECU)

[Name of the Document]　　Abstract

[Object]　The object of the present invention is to provide a malfunction detecting apparatus for an air-fuel ratio detecting apparatus, which is less susceptible to influence of catalyst storage ability and ensures number of times of detection.

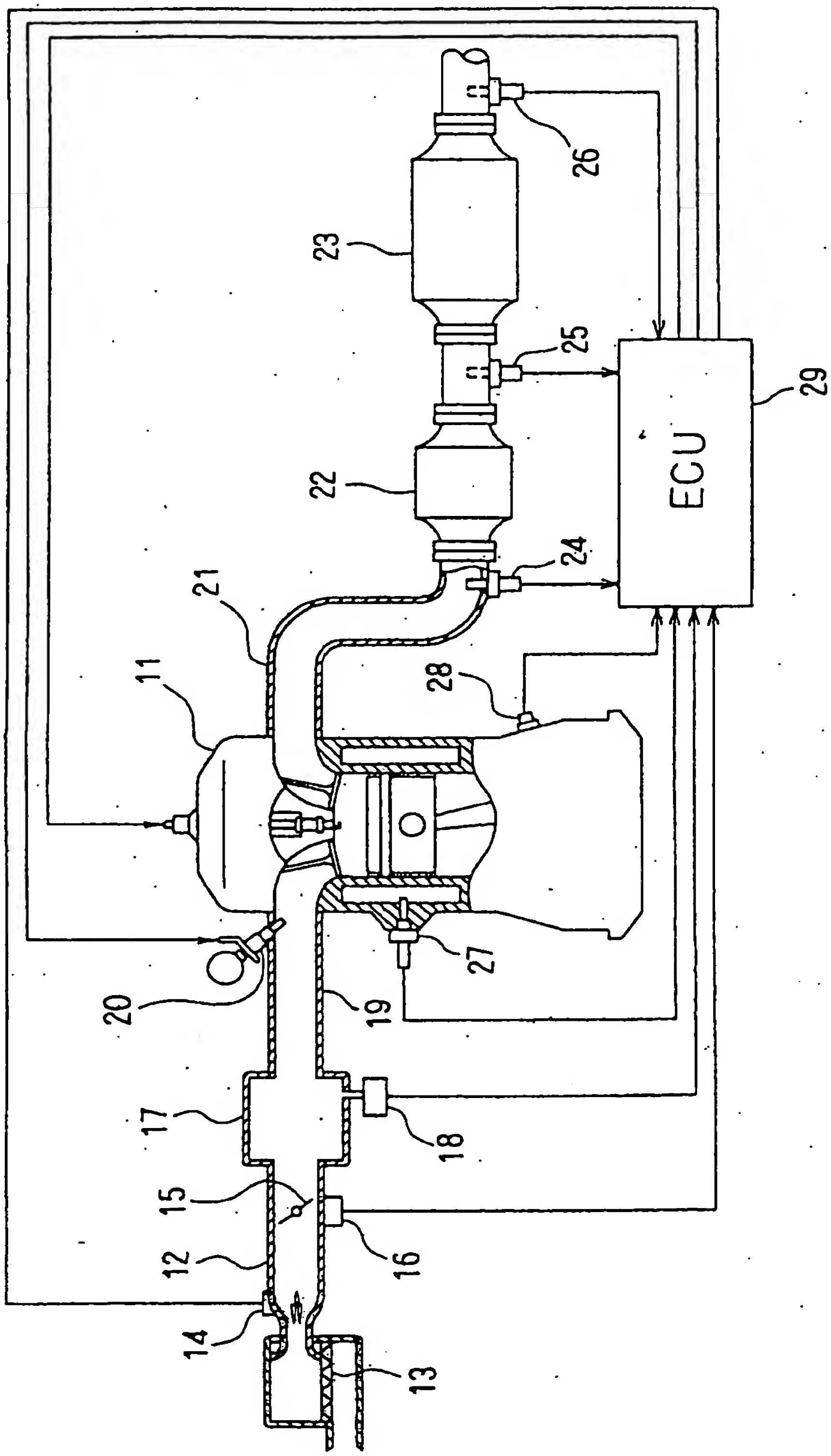
[Solution]　A change speed integrated value sdloxsl is calculated at low temperature control time when an element temperature of a solid electrolyte is stabilized at a low temperature. Successively, at this time, a change speed integrated value sdloxsh is calculated at high temperature control time when the solid electrolyte element is stabilized at a high temperature. Finally, a change speed integrated value deviation amount delxhl which is a deviation between the change speed integrated value sdloxsl at the low temperature control time and the change speed integrated value sdloxsh at the high temperature control time is calculated. By comparing the deviation amount delxhl with a predetermined determinant, presence or absence of the deterioration is determined.

[Selected Figure] Fig. 15

【書類名】　図面

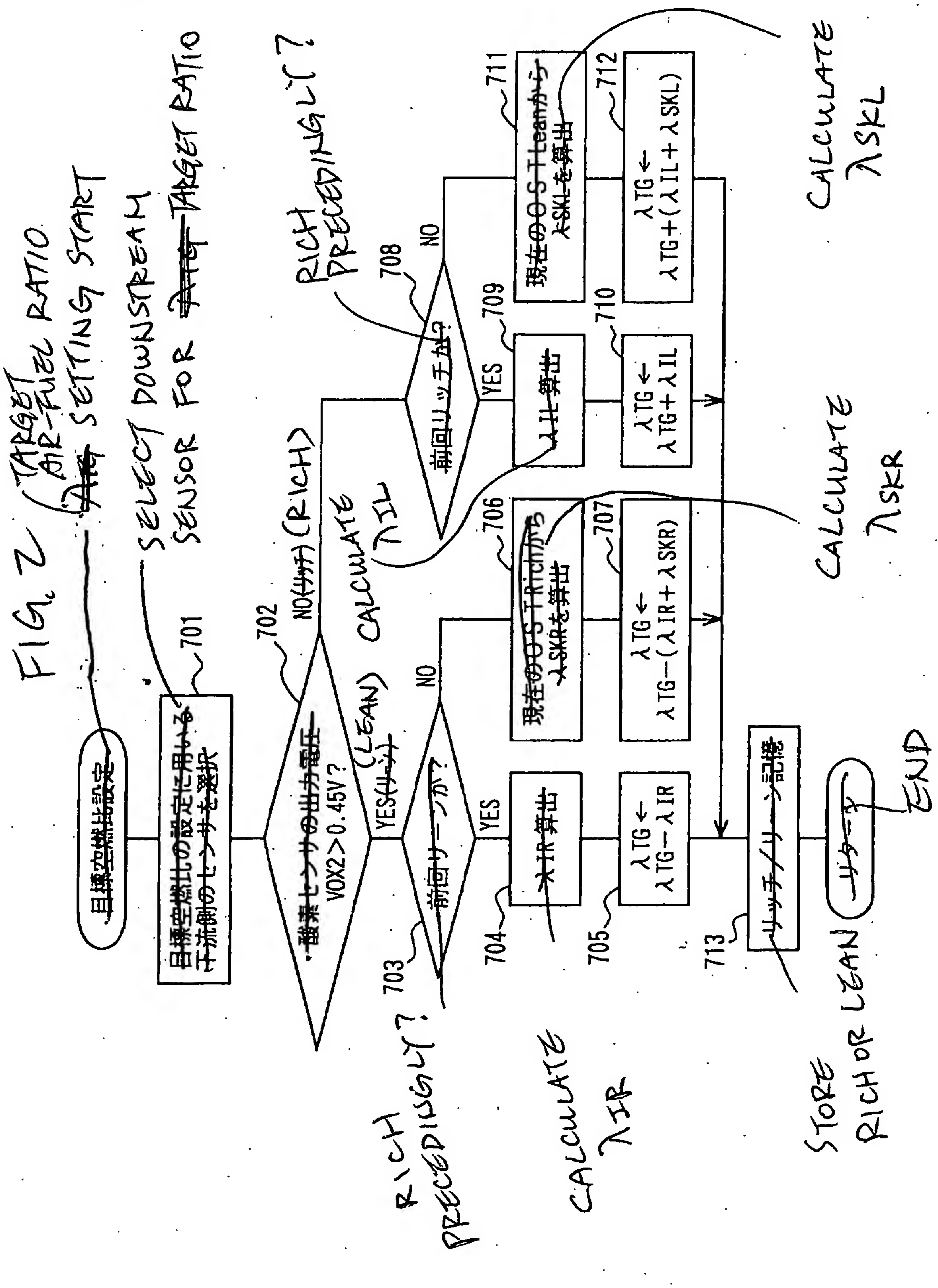
【図１】

FIG. 1


11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
ECU

【図２】

FIG. 2


~~目標空燃比設定~~
TARGET AIR-FUEL RATIO ~~λTG~~ SETTING START
701
~~目標空燃比の設定に用いる下流側のセンサを選択~~
SELECT DOWNSTREAM SENSOR FOR ~~λTG~~ TARGET RATIO
702
~~酸素センサの出力電圧~~ VOX2>0.45V?
YES(~~リーン~~) (LEAN)
NO(~~リッチ~~) (RICH)
703
~~前回リーンか?~~
RICH PRECEDINGLY?
YES
NO
704
~~λIR算出~~
CALCULATE λIR
705
λTG←
λTG−λIR
706
~~現在のOST richから~~
~~λSKRを算出~~
CALCULATE λSKR
707
λTG←
λTG−(λIR+λSKR)
708
~~前回リッチか?~~
RICH PRECEDINGLY?
YES
NO
709
~~λIL算出~~
CALCULATE λIL
710
λTG←
λTG+λIL
711
~~現在のOST leanから~~
~~λSKLを算出~~
CALCULATE λSKL
712
λTG←
λTG+(λIL+λSKL)
713
~~リッチ/リーン記憶~~
STORE RICH OR LEAN
~~リターン~~
END

【図３】

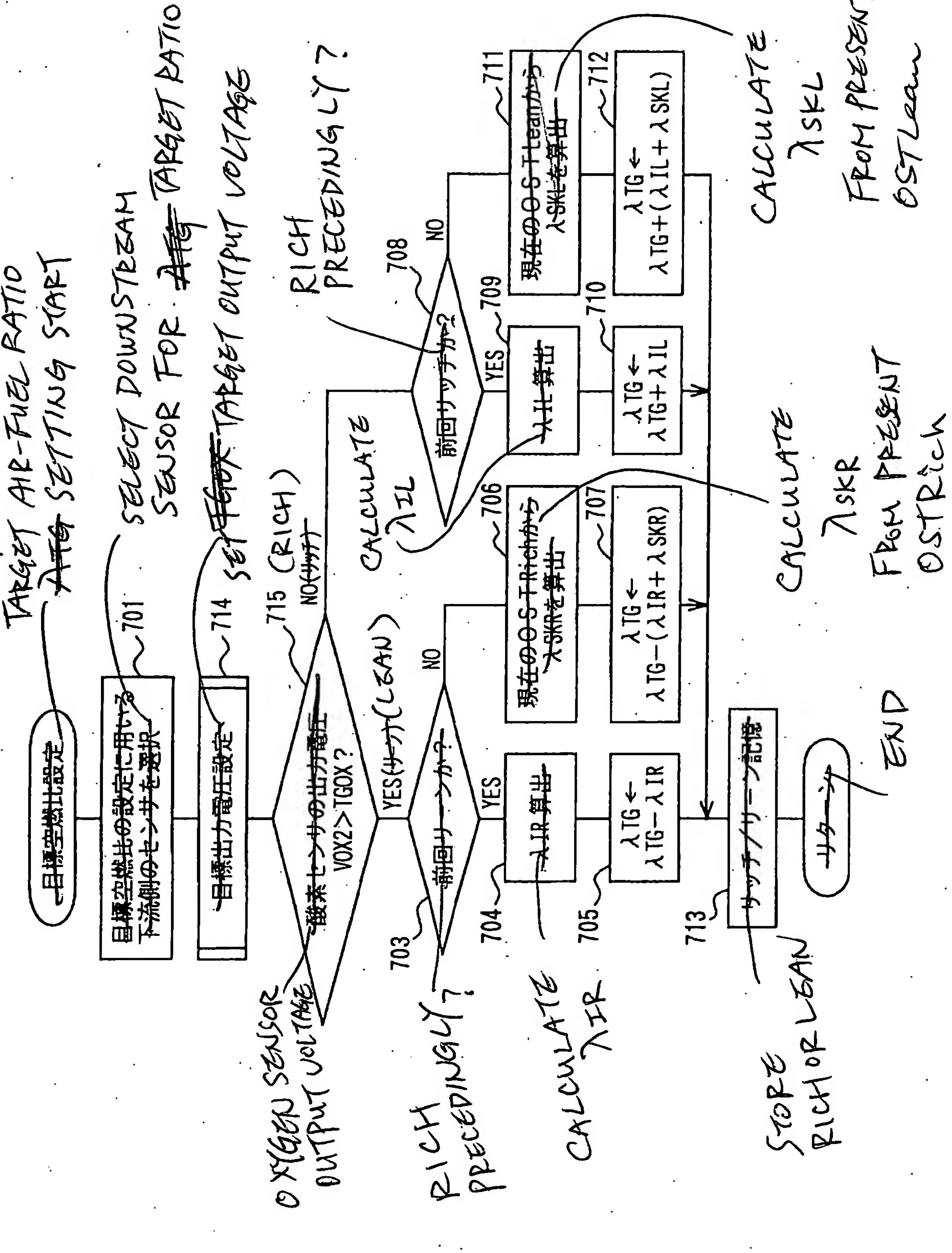
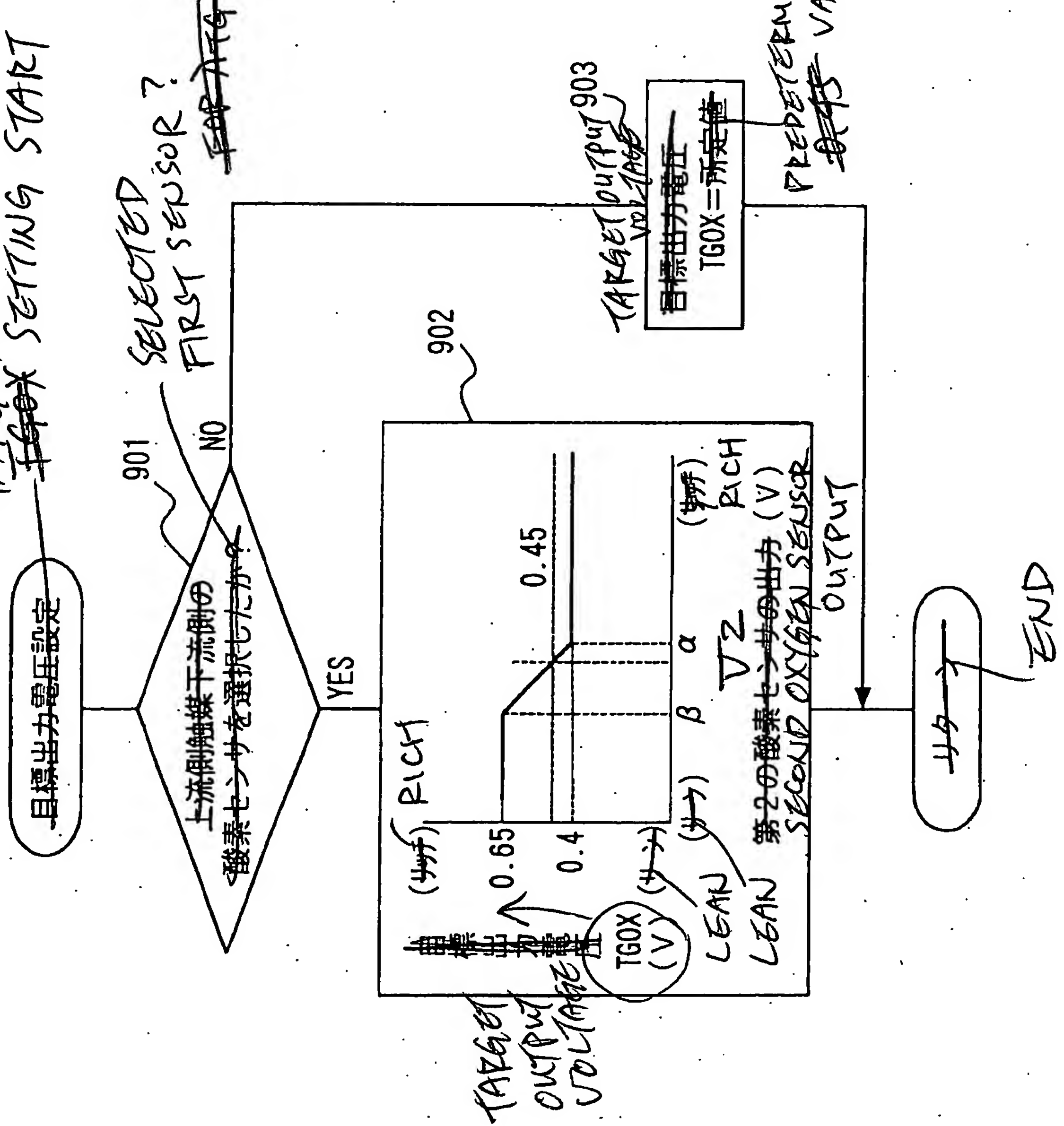


FIG. 3
TARGET AIR-FUEL RATIO λTG SETTING START
目標空燃比設定
701
目標空燃比の設定に用いる下流側のセンサを選択
SELECT DOWNSTREAM SENSOR FOR λTG TARGET RATIO
714
目標出力電圧設定
SET TGOX TARGET OUTPUT VOLTAGE
715
酸素センサの出力電圧 VOX2>TGOX？
OXYGEN SENSOR OUTPUT VOLTAGE
YES(リーン) (LEAN)
NO(リッチ) (RICH)
703
前回リーンか？
RICH PRECEDINGLY?
YES
NO
704
λIR算出
CALCULATE λIR
705
λTG← λTG−λIR
706
現在のOSTrichから λSKRを算出
CALCULATE λSKR FROM PRESENT OSTRich
707
λTG← λTG−(λIR+λSKR)
708
前回リッチか？
RICH PRECEDINGLY?
YES
NO
709
λIL算出
CALCULATE λIL
710
λTG← λTG+λIL
711
現在のOSTleanから λSKLを算出
CALCULATE λSKL FROM PRESENT OSTLean
712
λTG← λTG+(λIL+λSKL)
713
リッチ/リーン記憶
STORE RICH OR LEAN
リターン
END

【図４】

FIG. 4


~~目標出力電圧設定~~
TARGET OUTPUT VOLTAGE ~~TGOX~~ SETTING START
901
~~上流側触媒下流側の酸素センサを選択したか？~~
SELECTED FIRST SENSOR ?
~~FOR FIG. 7~~
NO
YES
902
~~目標出力電圧~~
TGOX (V)
TARGET OUTPUT VOLTAGE
~~(リッチ)~~ RICH
0.65
0.4
~~(リーン)~~ LEAN
0.45
α
β
~~(リーン)~~ LEAN
~~(リッチ)~~ RICH
(V)
~~第２の酸素センサの出力~~
V2
SECOND OXYGEN SENSOR OUTPUT
903
~~目標出力電圧~~
TARGET OUTPUT VOLTAGE
TGOX=~~所定値~~
PREDETERMINED ~~値~~ VALUE
~~リターン~~
END

【図５】

FIG. 5

~~FIG. 5A~~
~~(a)~~
(a)

FIRST OXYGEN SENSOR MAP
~~第１の酸素センサ用マップ~~

QA ~~吸入空気量（QA）~~ (g/s)	5	10	15	20	30	40	50
RICH INTEGRATION ~~リッチ積分量~~λIR	0.12	0.08	0.05	0.04	0.03	0.02	0.01
LEAN INTEGRATION ~~リーン積分量~~λIL	0.12	0.08	0.04	0.03	0.02	0.01	0.01

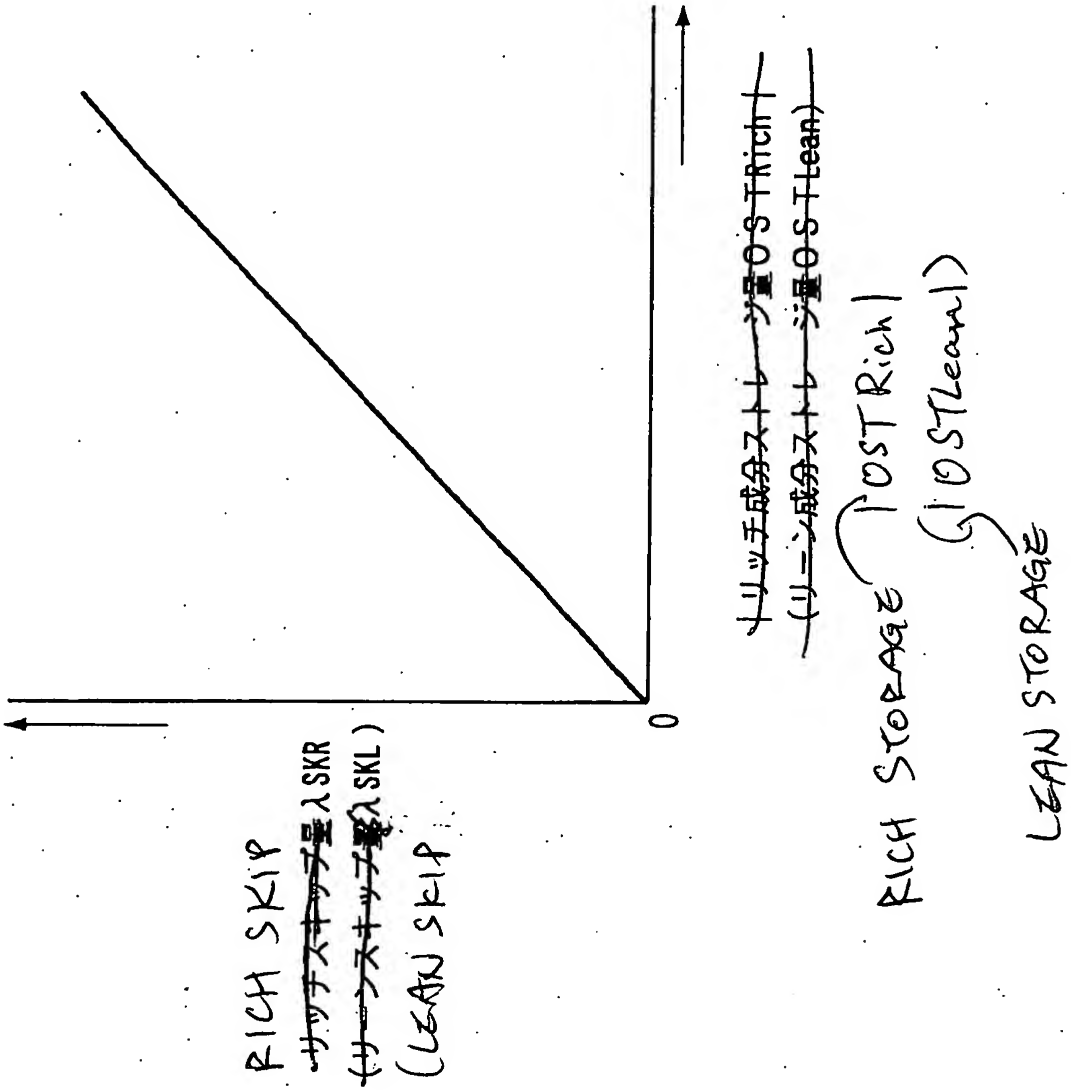
~~FIG. 5B~~
~~(b)~~
(b)

SECOND OXYGEN SENSOR MAP
~~第２の酸素センサ用マップ~~

QA ~~吸入空気量（QA）~~ (g/s)	5	10	15	20	30	40	50
RICH INTEGRATION ~~リッチ積分量~~λIR	0.15	0.1	0.07	0.05	0.03	0.02	0.01
LEAN INTEGRATION ~~リーン積分量~~λIL	0.15	0.1	0.05	0.03	0.02	0.01	0.01

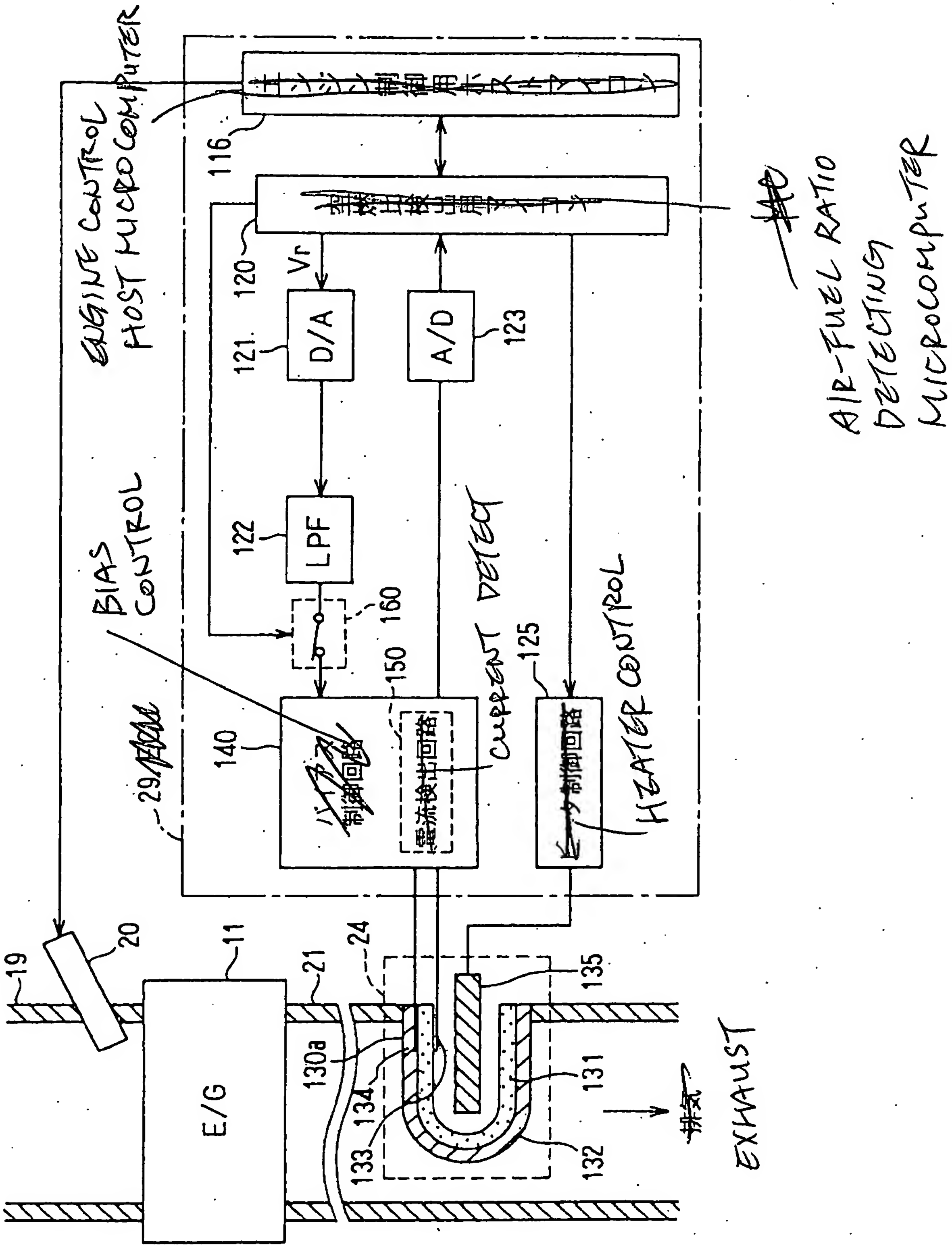
【図６】

FIG. 6


0
~~リッチ成分ストレージ量ＯＳＴRich~~
~~(リーン成分ストレージ量ＯＳＴLean)~~
RICH STORAGE
OST Rich
(OST Lean)
LEAN STORAGE
RICH SKIP
~~リッチスキップ量λSKR~~
~~(リーンスキップ量λSKL)~~
(LEAN SKIP

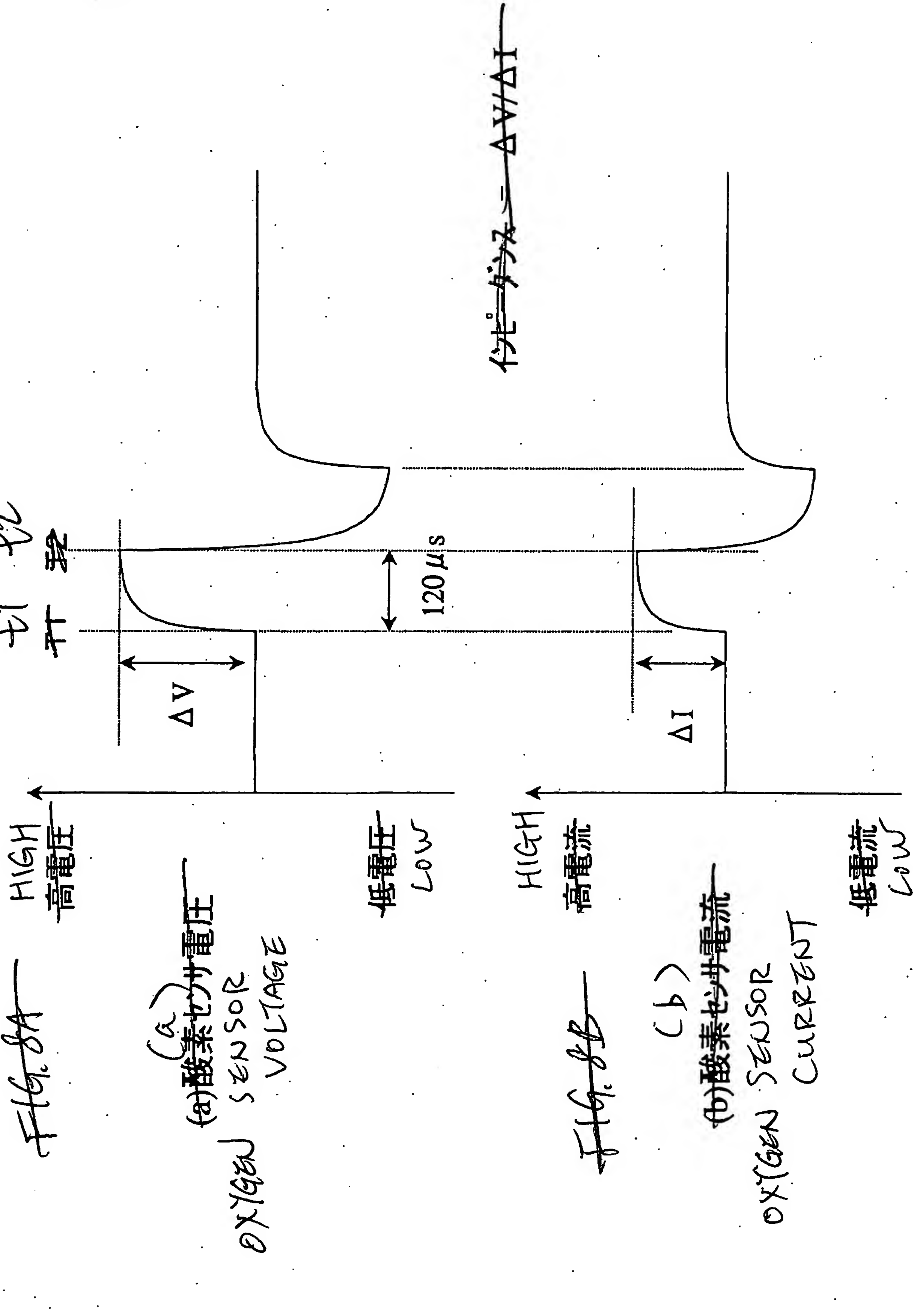
【図７】

FIG. 7


116
~~エンジン制御用ホストマイコン~~
ENGINE CONTROL HOST MICROCOMPUTER
120
~~空燃比検出用マイコン~~
AIR-FUEL RATIO DETECTING MICROCOMPUTER
Vr
121
D/A
A/D
123
122
LPF
160
150
140
~~バイアス~~制御回路
BIAS CONTROL
電流検出回路
CURRENT DETECT
125
~~ヒータ~~制御回路
HEATER CONTROL
29
19
20
11
E/G
21
24
130a
134
133
135
131
132
~~排気~~
EXHAUST

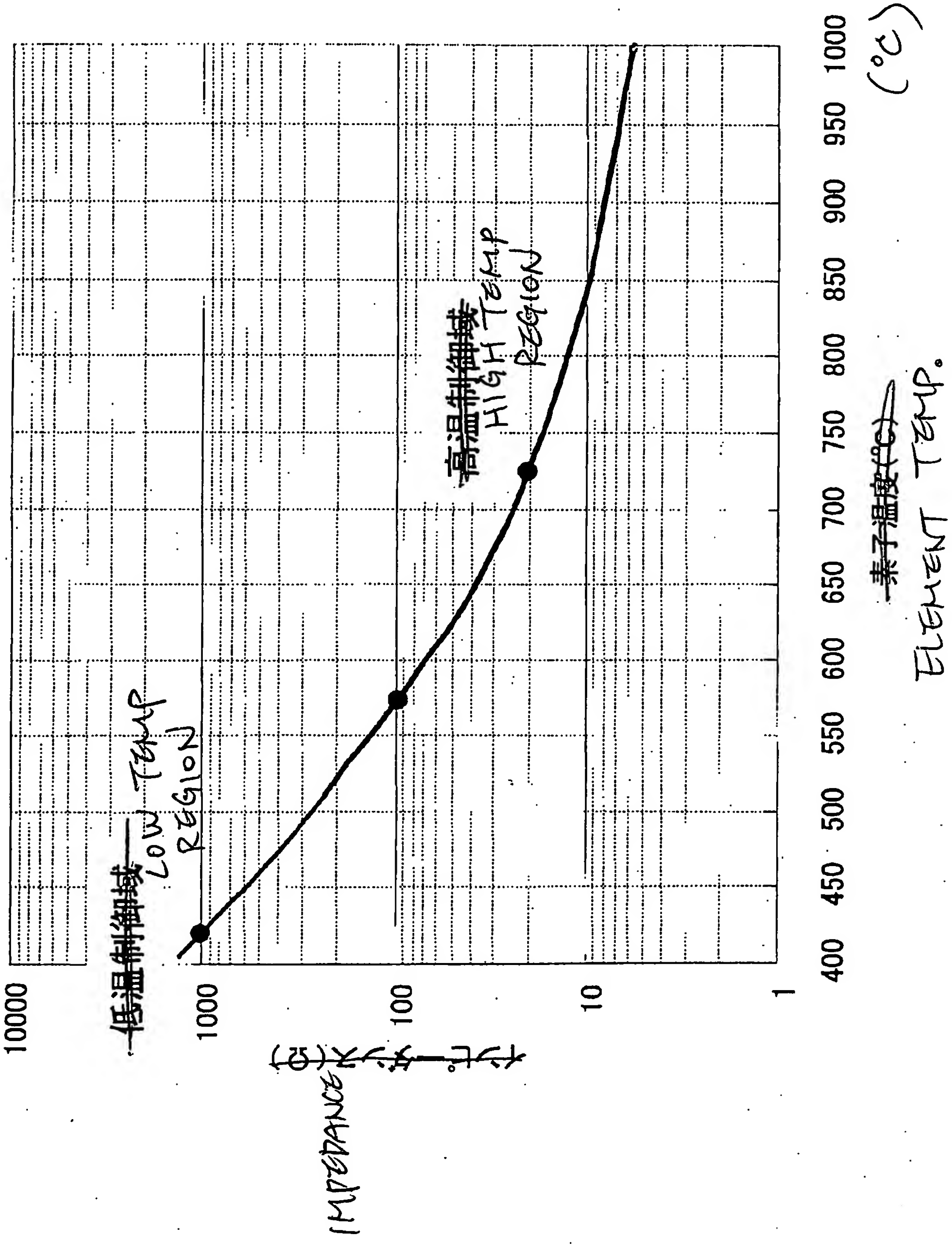
【図８】

FIG. 8


~~インピーダンス＝ΔV/ΔI~~
t1
t2
120μs
ΔV
ΔI
HIGH
~~高電圧~~
~~低電圧~~
LOW
HIGH
~~高電流~~
~~低電流~~
LOW
~~FIG. 8A~~
(a)
~~(a)酸素センサ電圧~~
OXYGEN SENSOR VOLTAGE
~~FIG. 8B~~
(b)
~~(b)酸素センサ電流~~
OXYGEN SENSOR CURRENT

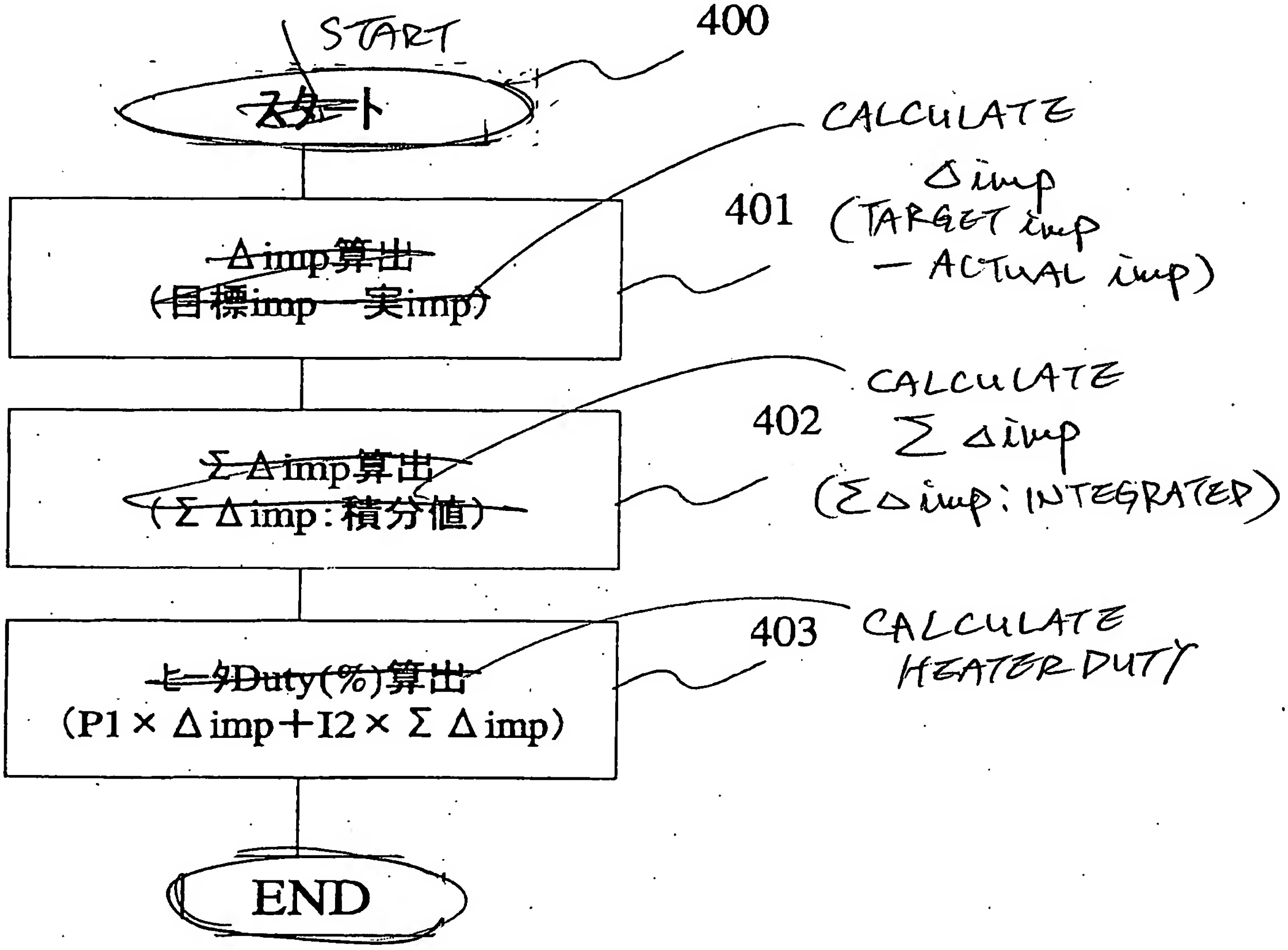
【図９】

FIG. 9


(Ω)
10000
1000
100
10
1
~~インピーダンス(Ω)~~
IMPEDANCE
400
450
500
550
600
650
700
750
800
850
900
950
1000
(°C)
~~素子温度(℃)~~
ELEMENT TEMP.
~~低温制御域~~
LOW TEMP REGION
~~高温制御域~~
HIGH TEMP REGION

【図１０】

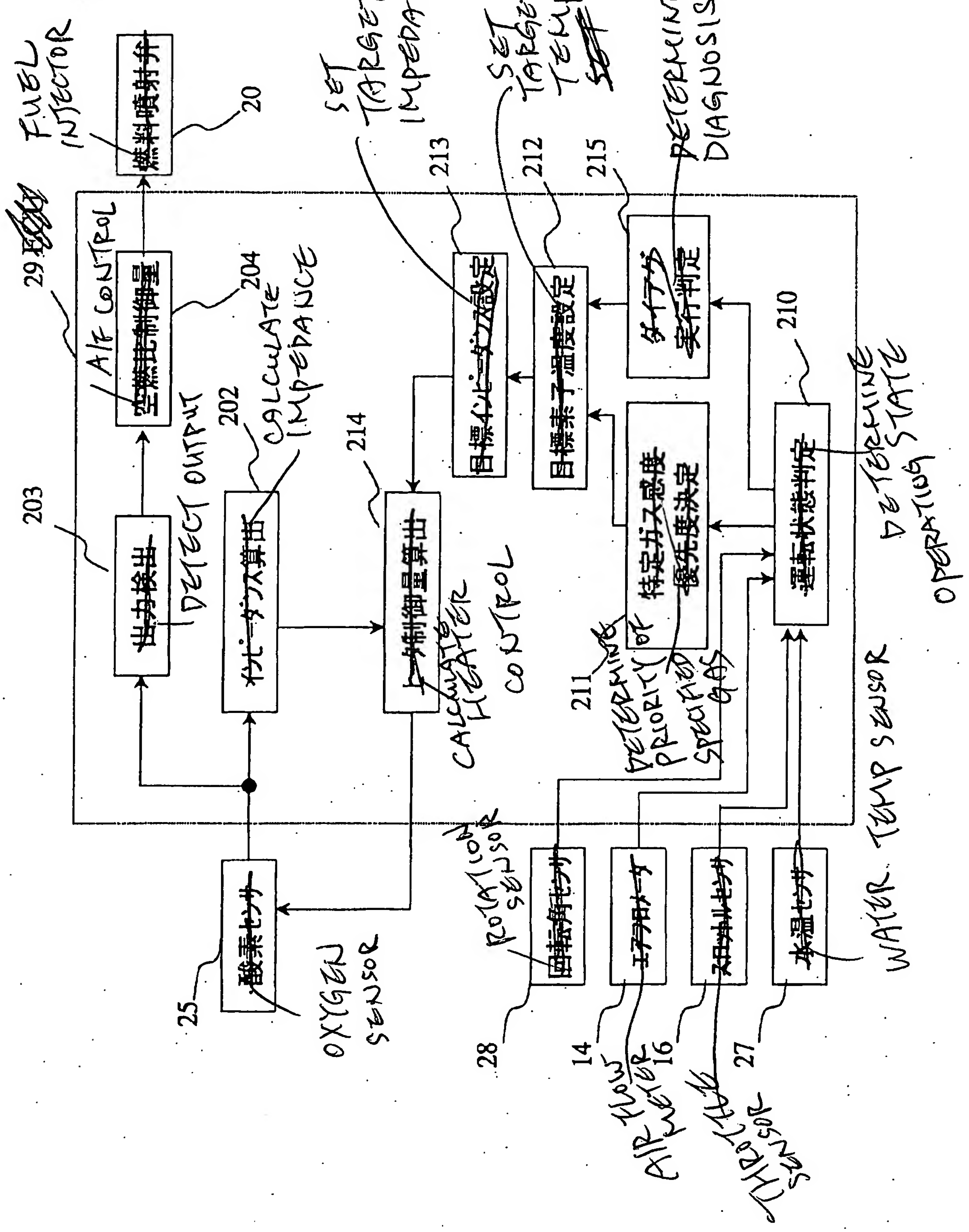
FIG. 10



START
~~スタート~~
400
~~Δimp算出~~
~~（目標imp－実imp）~~
401
CALCULATE
Δimp
(TARGET imp
– ACTUAL imp)
~~ΣΔimp算出~~
~~（ΣΔimp：積分値）~~
402
CALCULATE
ΣΔimp
(ΣΔimp: INTEGRATED)
~~ヒータDuty(%)算出~~
（P1×Δimp＋I2×ΣΔimp）
403
CALCULATE
HEATER DUTY
END

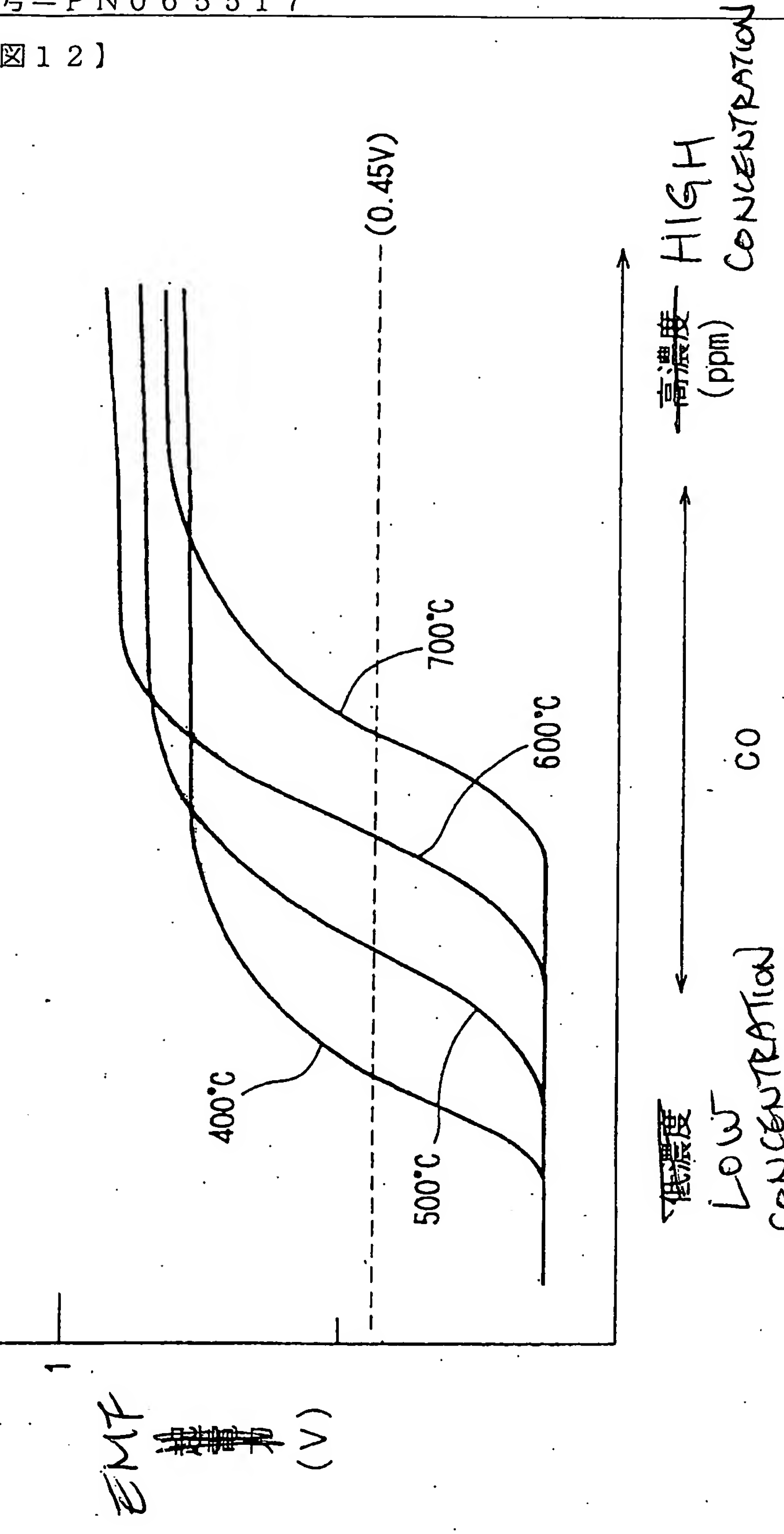
【図１１】

FIG. 11


~~燃料噴射弁~~
FUEL INJECTOR
20
29 ~~ECU~~
~~空燃比制御量~~
AIR CONTROL
204
~~出力検出~~
DETECT OUTPUT
203
~~インピーダンス算出~~
CALCULATE IMPEDANCE
202
~~ヒータ制御量算出~~
CALCULATE HEATER CONTROL
214
~~目標インピーダンス設定~~
SET TARGET IMPEDANCE
213
~~目標素子温度設定~~
SET TARGET TEMP ~~SET~~
212
~~ダイアグ実行判定~~
DETERMINE DIAGNOSIS
215
~~特定ガス感度優先度決定~~
DETERMINING OF PRIORITY OF SPECIFIED GAS
211
~~運転状態判定~~
DETERMINE OPERATING STATE
210
~~酸素センサ~~
OXYGEN SENSOR
25
~~回転角センサ~~
ROTATION SENSOR
28
~~エアフロメータ~~
AIR FLOW METER
14
~~スロットルセンサ~~
THROTTLE SENSOR
16
~~水温センサ~~
WATER TEMP SENSOR
27

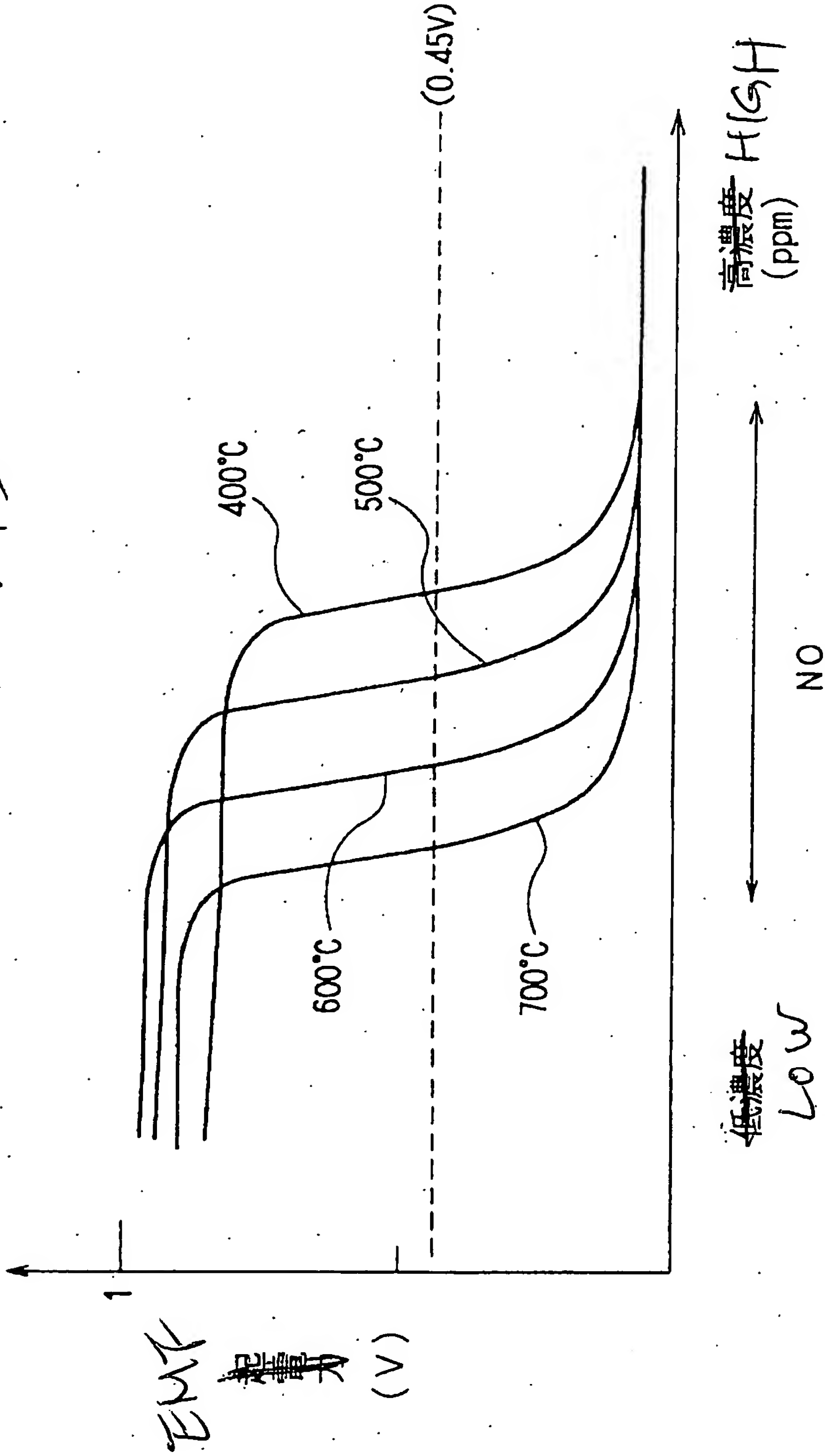
【図１２】

FIG. 12


(0.45V)
HIGH CONCENTRATION
~~高濃度~~
(ppm)
CO
~~低濃度~~
LOW CONCENTRATION
700°C
600°C
500°C
400°C
1
~~EMF~~
EMF ~~起電力~~ (V)

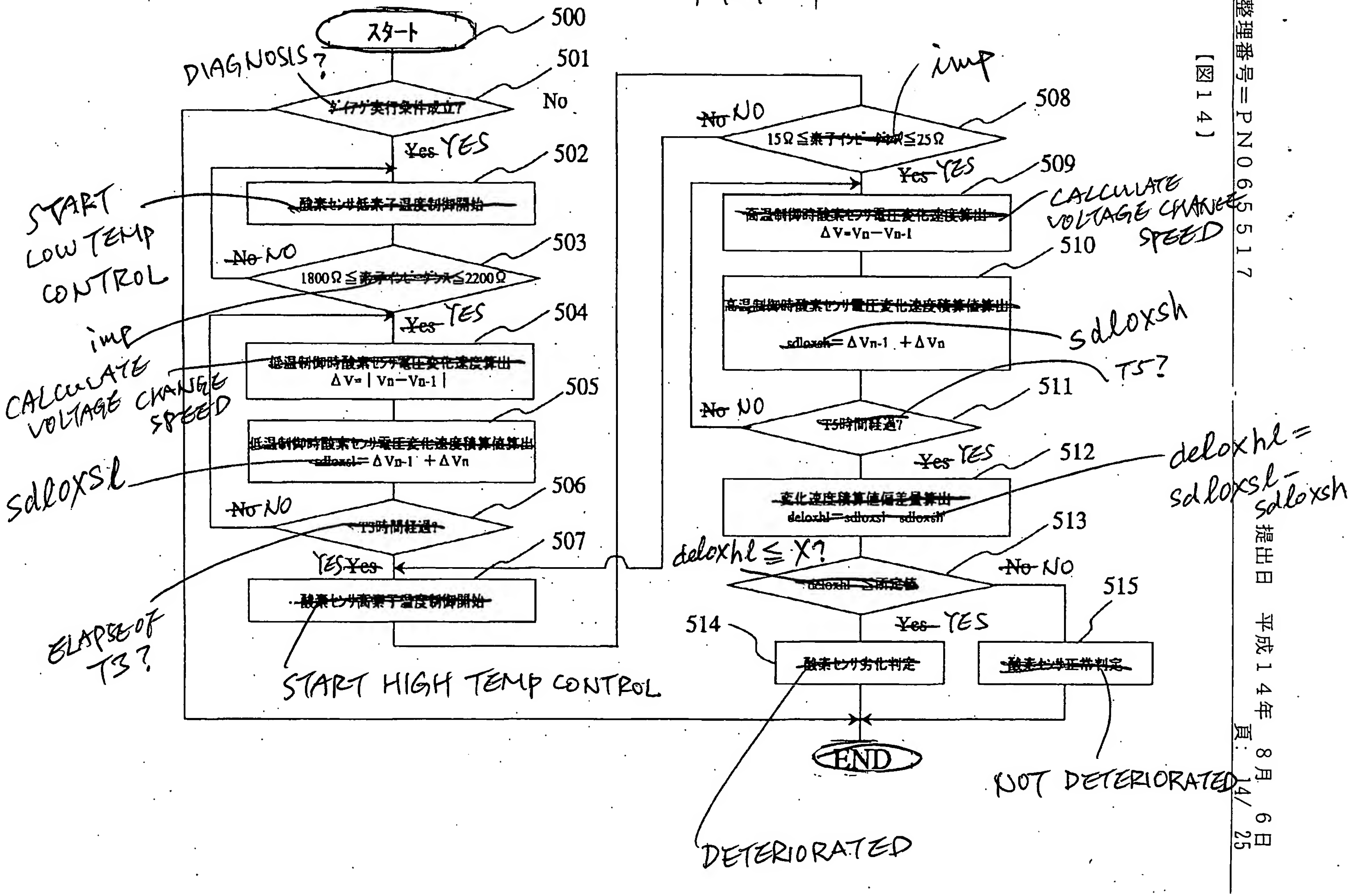
【図１３】

FIG. 13



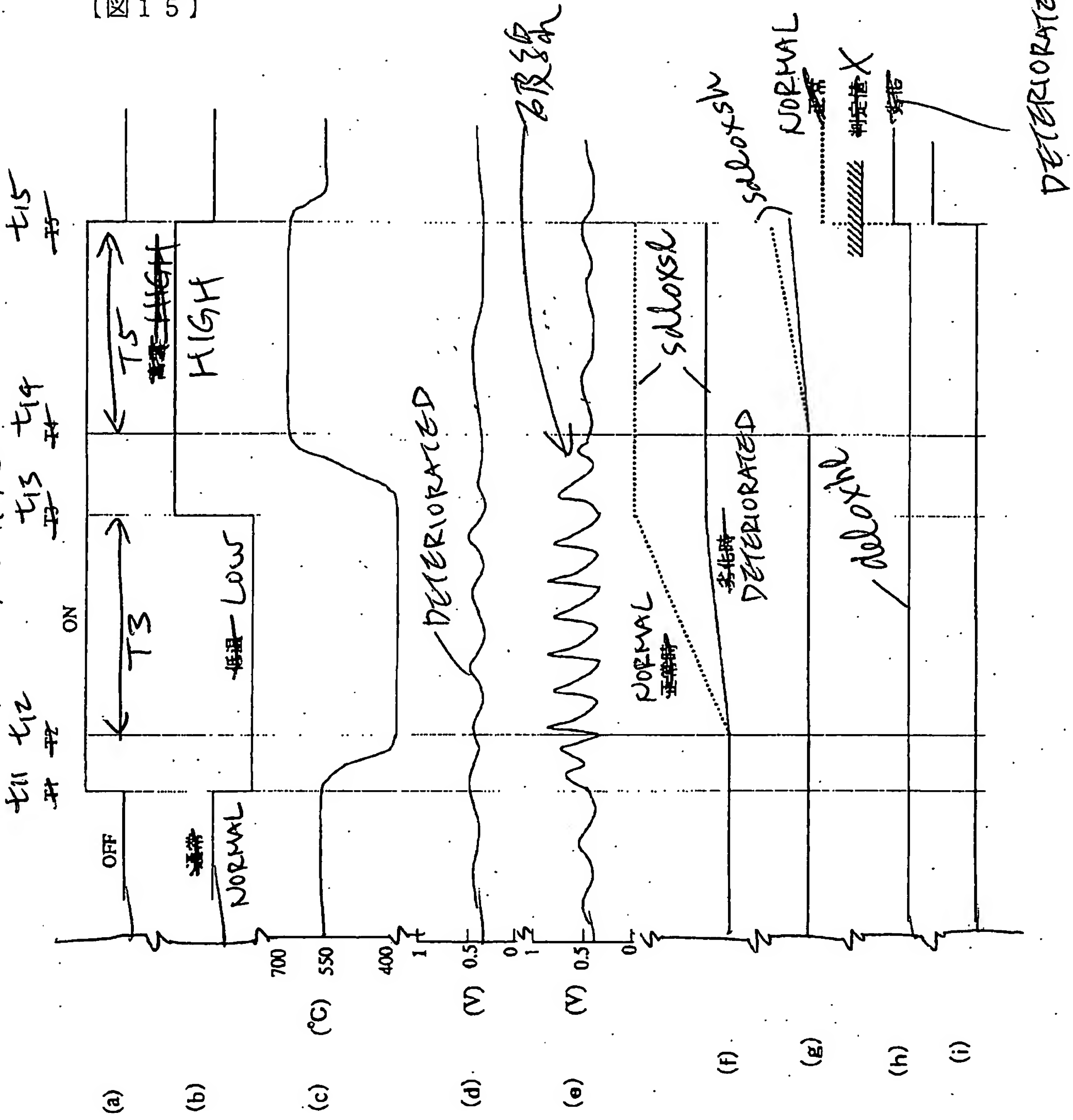
【図１４】

FIG. 14


500
スタート
501
DIAGNOSIS?
~~ダイアグ実行条件成立?~~
No
~~Yes~~ YES
502
~~酸素センサ低素子温度制御開始~~
START LOW TEMP CONTROL
~~No~~ NO
503
1800Ω≦~~素子インピーダンス~~≦2200Ω
imp
~~Yes~~ YES
504
~~低温制御時酸素センサ電圧変化速度算出~~
ΔV=|Vn−Vn-1|
CALCULATE VOLTAGE CHANGE SPEED
505
~~低温制御時酸素センサ電圧変化速度積算値算出~~
~~sdloxsl~~=ΔVn-1 +ΔVn
sdloxsl
~~No~~ NO
506
~~T3時間経過?~~
ELAPSE OF T3?
YES ~~Yes~~
507
~~酸素センサ高素子温度制御開始~~
START HIGH TEMP CONTROL
imp
~~No~~ NO
508
15Ω≦~~素子インピーダンス~~≦25Ω
~~Yes~~ YES
509
~~高温制御時酸素センサ電圧変化速度算出~~
ΔV=Vn−Vn-1
CALCULATE VOLTAGE CHANGE SPEED
510
~~高温制御時酸素センサ電圧変化速度積算値算出~~
~~sdloxsh~~=ΔVn-1 +ΔVn
sdloxsh
T5?
~~No~~ NO
511
~~T5時間経過?~~
~~Yes~~ YES
512
~~変化速度積算値偏差量算出~~
~~deloxhl=sdloxsl−sdloxsh~~
deloxhl= sdloxsl−sdloxsh
deloxhl≦X?
513
~~deloxhl≦所定値~~
~~No~~ NO
~~Yes~~ YES
514
~~酸素センサ劣化判定~~
515
~~酸素センサ正常判定~~
END
DETERIORATED
NOT DETERIORATED

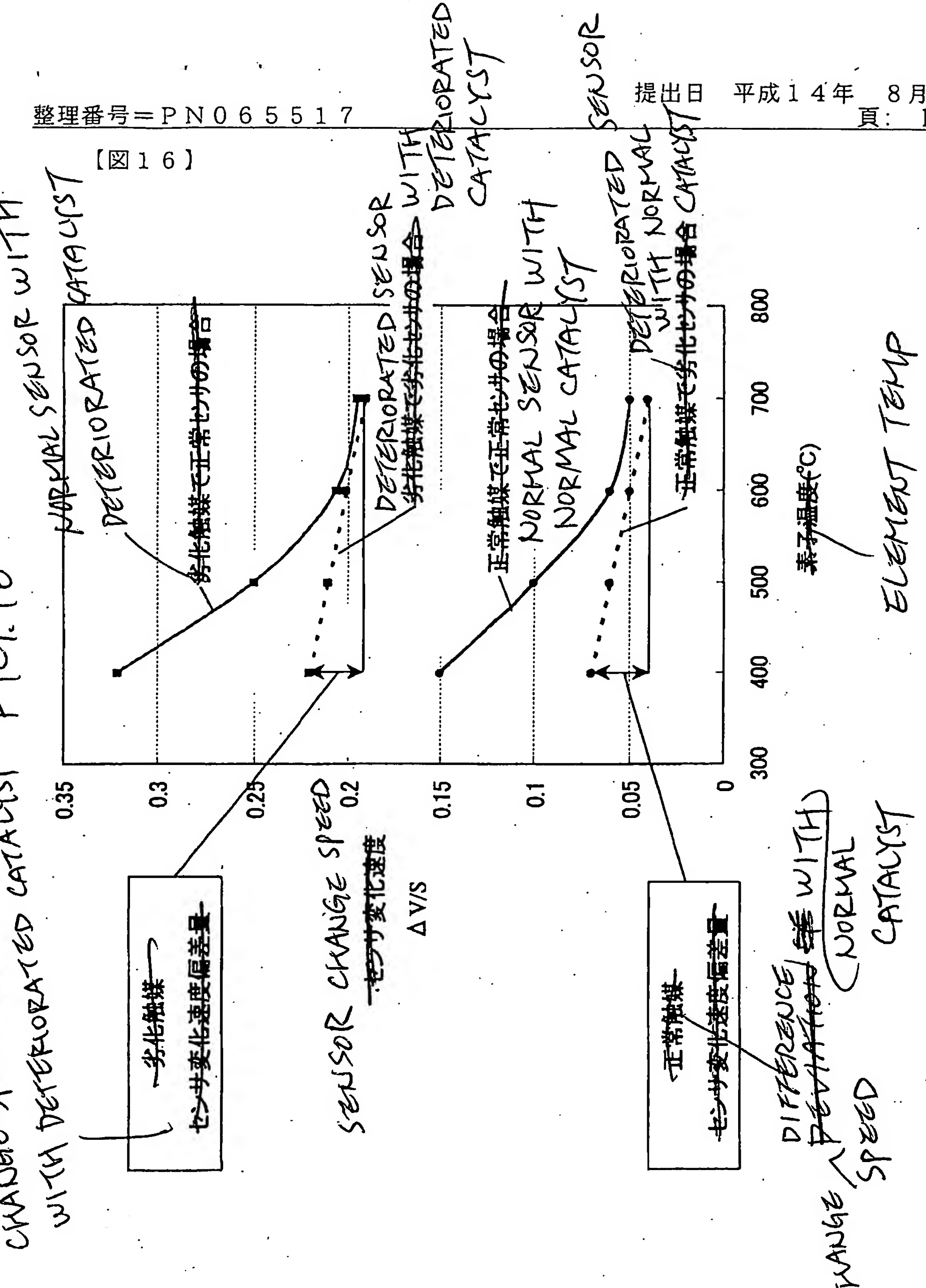
【図１５】

FIG. 15


(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
OFF
ON
~~通常~~ NORMAL
~~低温~~ LOW
~~高温~~ ~~HIGH~~ HIGH
T3
T5
t11
t12
t13
t14
t15
700
550
400
(°C)
1
0.5
0
(V)
DETERIORATED
~~正常時~~ NORMAL
~~劣化時~~ DETERIORATED
saloxsl
saloxsh
deloxhl
~~正常~~ NORMAL
~~判定値~~ X
~~劣化~~ DETERIORATED

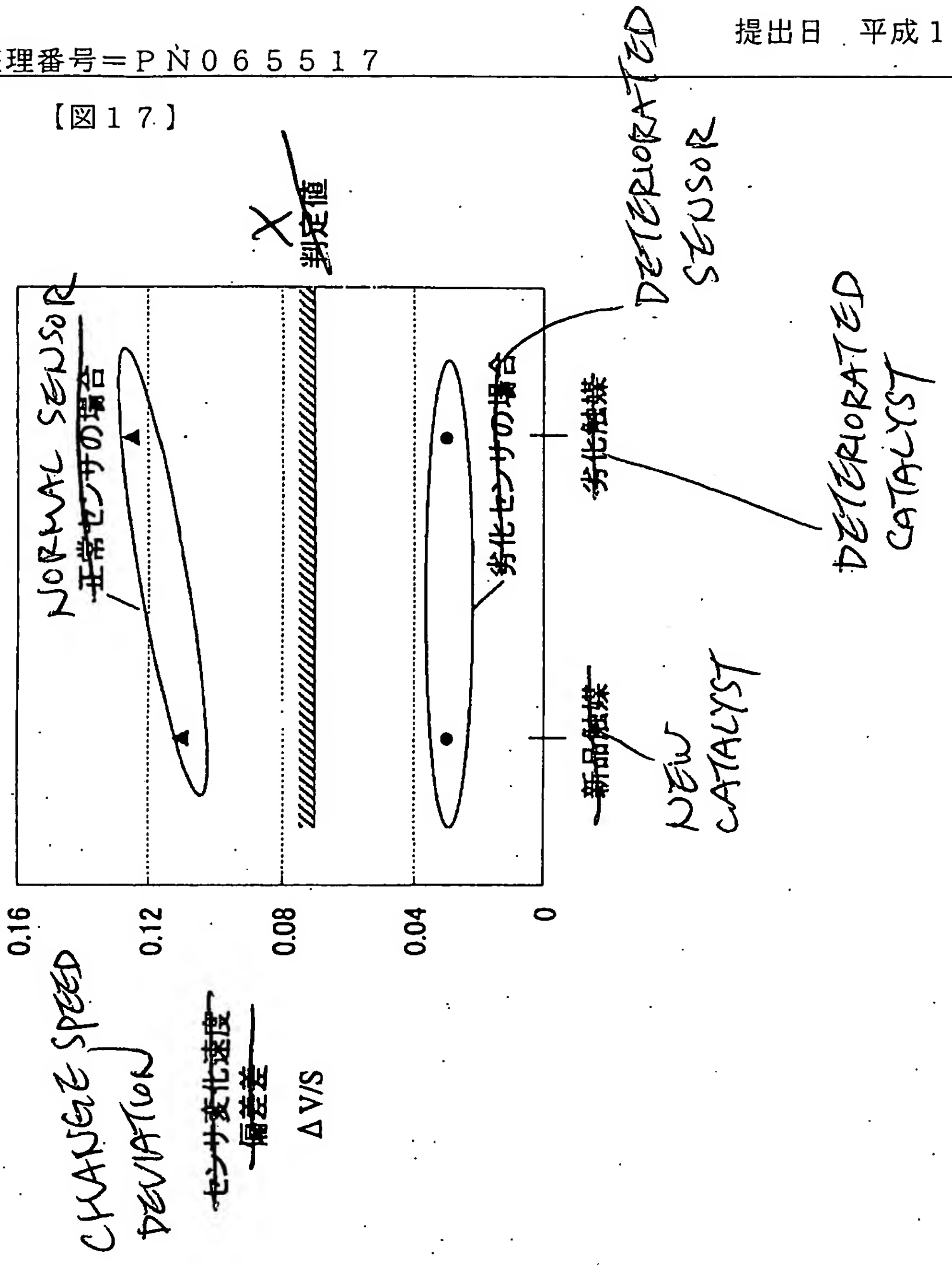
【図１６】

FIG. 16


~~劣化触媒で正常センサの場合~~
~~NORMAL~~ NORMAL SENSOR WITH DETERIORATED CATALYST
~~劣化触媒で劣化センサの場合~~
DETERIORATED SENSOR WITH DETERIORATED CATALYST
~~正常触媒で正常センサの場合~~
NORMAL SENSOR WITH NORMAL CATALYST
~~正常触媒で劣化センサの場合~~
DETERIORATED SENSOR WITH NORMAL CATALYST
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
300
400
500
600
700
800
~~センサ変化速度~~
SENSOR CHANGE SPEED
ΔV/S
~~素子温度~~(℃)
ELEMENT TEMP
~~劣化触媒~~
~~センサ変化速度偏差量~~
CHANGE SPEED DIFFERENCE ~~DEVIATION~~ WITH DETERIORATED CATALYST
~~正常触媒~~
~~センサ変化速度偏差量~~
DIFFERENCE ~~DEVIATION~~ CHANGE SPEED ~~率~~ WITH NORMAL CATALYST

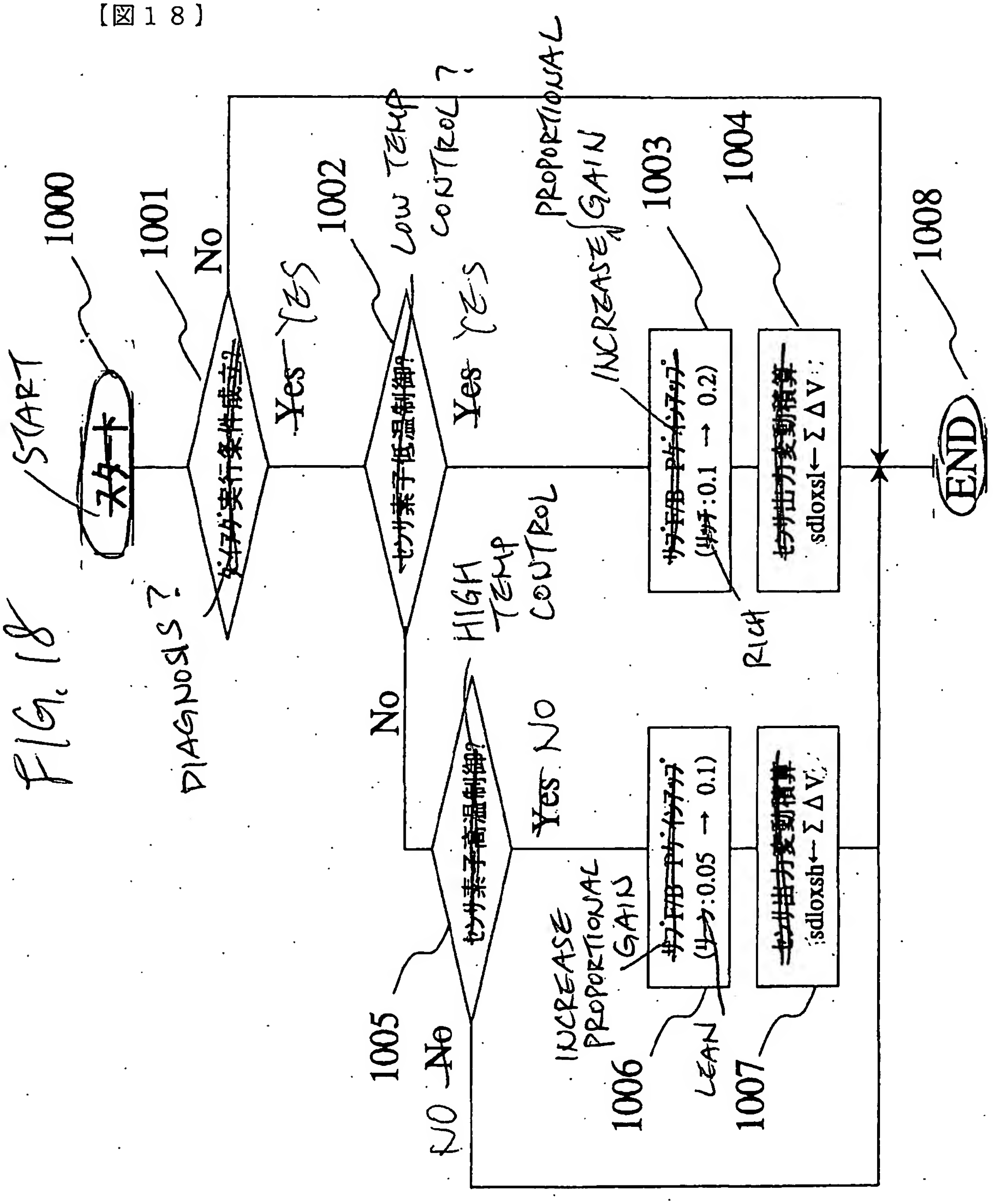
【図１７】

FIG. 17


~~判定値~~
X
~~正常センサの場合~~
NORMAL SENSOR
~~劣化センサの場合~~
DETERIORATED SENSOR
~~劣化触媒~~
DETERIORATED CATALYST
~~新品触媒~~
NEW CATALYST
0.16
0.12
0.08
0.04
0
~~センサ変化速度偏差~~
CHANGE SPEED DEVIATION
ΔV/S

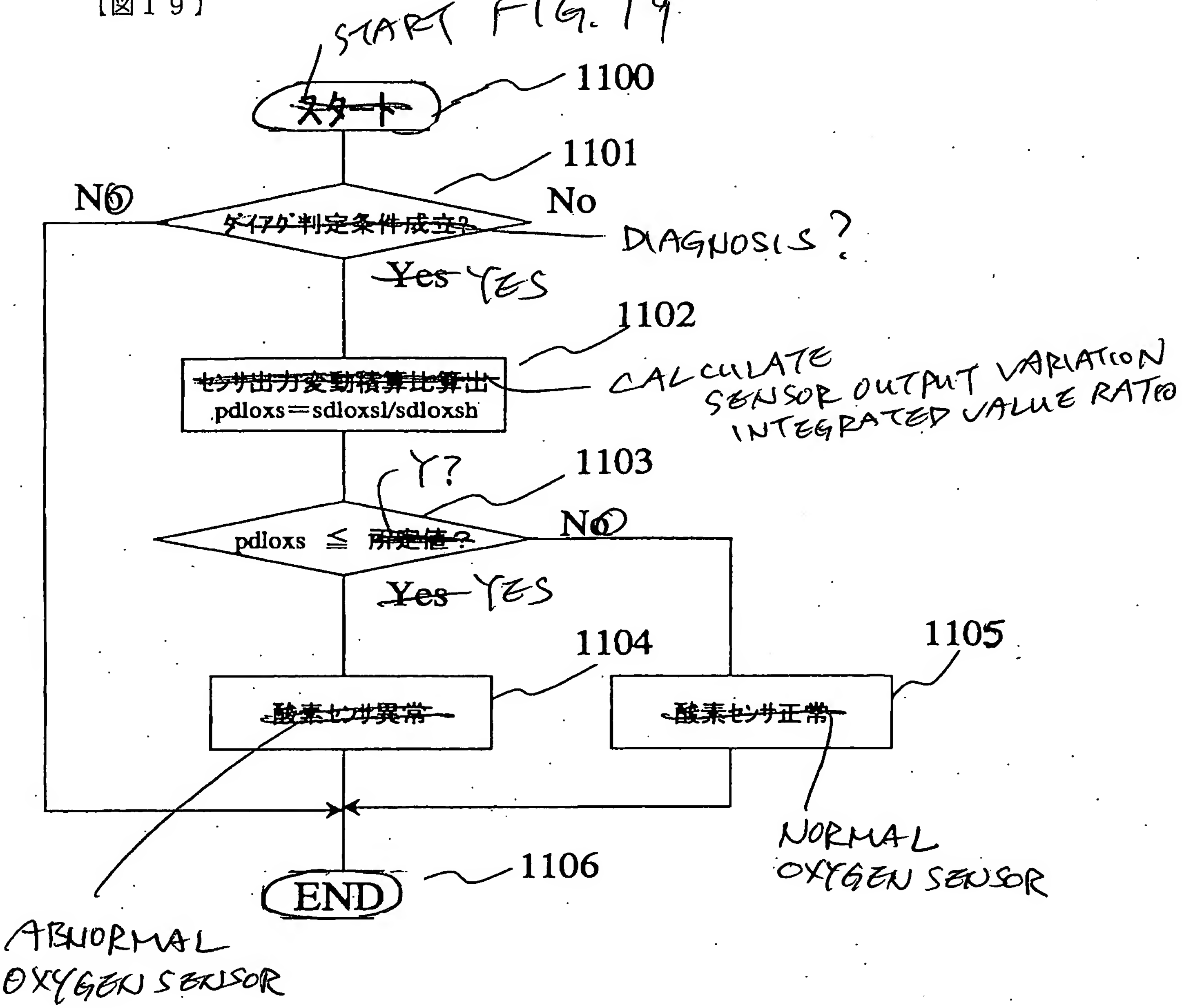
【図１８】

FIG. 18


START
~~スタート~~
1000
1001
DIAGNOSIS?
~~センサ実行条件成立?~~
No
~~Yes~~ YES
1002
LOW TEMP CONTROL?
~~センサ素子低温制御?~~
~~Yes~~ YES
No
HIGH TEMP CONTROL
~~センサ素子高温制御?~~
~~Yes~~ NO
1005
~~No~~ NO
PROPORTIONAL GAIN
INCREASE
1003
~~サブF/B・Pゲインアップ~~
(~~リッチ~~:0.1 → 0.2)
RICH
1004
~~センサ出力変動積算~~
;sdloxsl←ΣΔV;
INCREASE PROPORTIONAL GAIN
1006
~~サブF/B・Pゲインアップ~~
(~~リーン~~:0.05 → 0.1)
LEAN
1007
~~センサ出力変動積算~~
;sdloxsh←ΣΔV;
1008
END

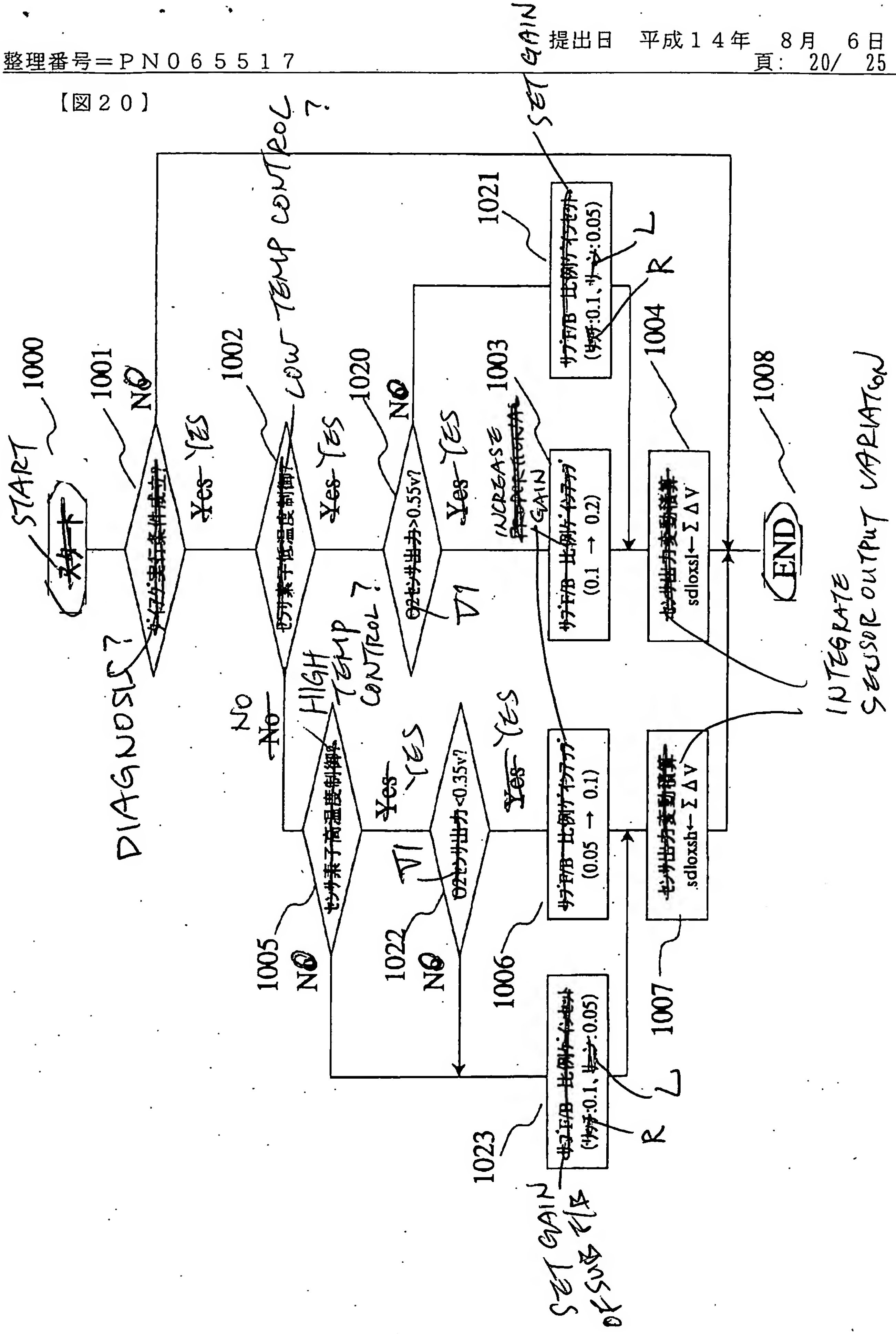
【図１９】

FIG. 19


START
~~スタート~~
1100
1101
NO
No
~~ダイアグ判定条件成立？~~
DIAGNOSIS ?
~~Yes~~ YES
1102
~~センサ出力変動積算比算出~~
pdloxs＝sdloxsl/sdloxsh
CALCULATE SENSOR OUTPUT VARIATION INTEGRATED VALUE RATIO
Y?
1103
pdloxs ≦ ~~所定値？~~
NO
~~Yes~~ YES
1104
~~酸素センサ異常~~
1105
~~酸素センサ正常~~
NORMAL OXYGEN SENSOR
1106
END
ABNORMAL OXYGEN SENSOR

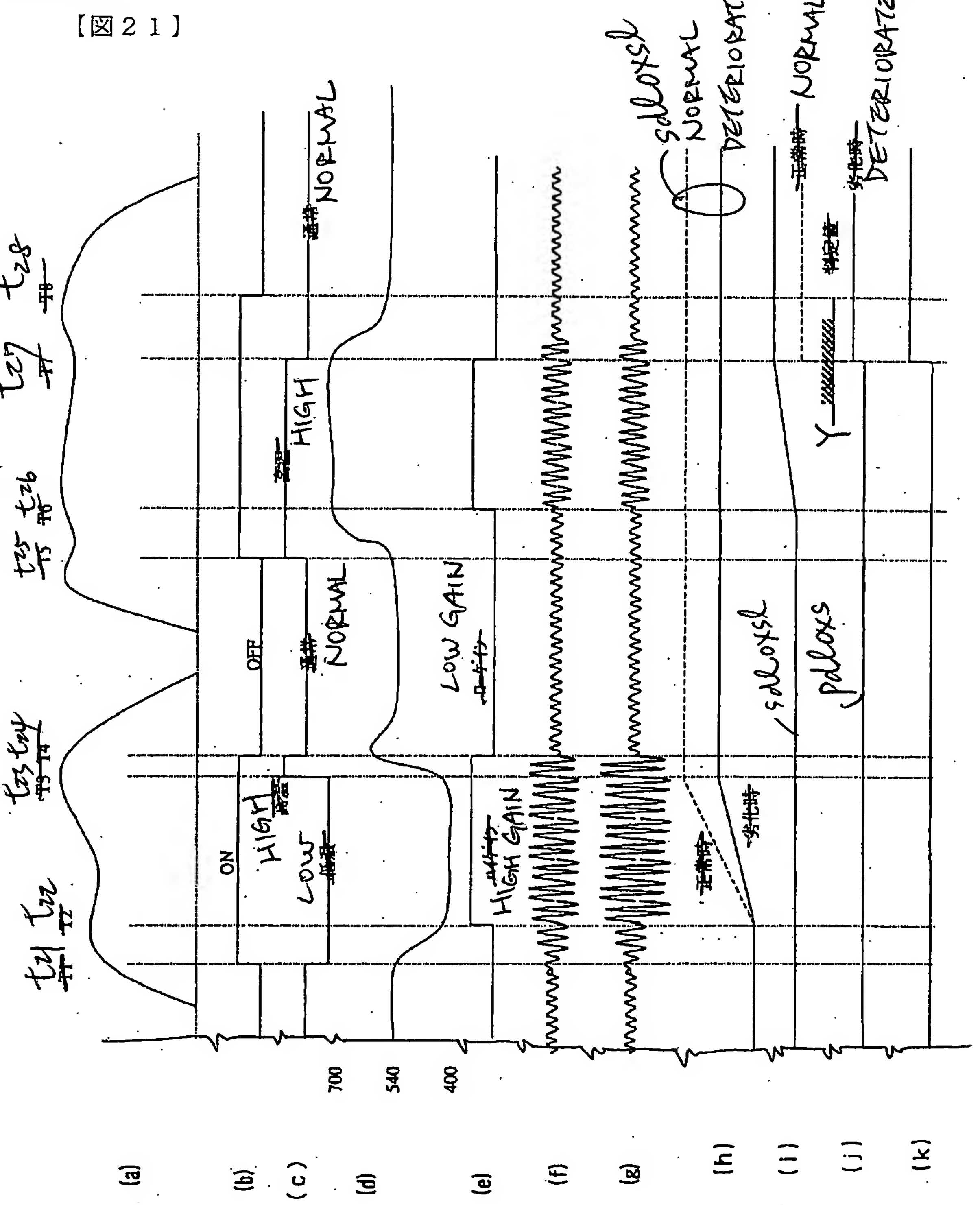
【図２０】

FIG. 20


1000
START
~~スタート~~
1001
~~サイクル実行条件成立~~
DIAGNOSIS?
NO
~~Yes~~ YES
1002
~~センサ素子低温度制御~~?
LOW TEMP CONTROL ?
~~Yes~~ YES
1020
~~O2センサ出力~~>0.55v?
V1
NO
~~Yes~~ YES
1021
~~サブF/B 比例ゲインセット~~
(~~リッチ~~:0.1, ~~リーン~~:0.05)
SET GAIN
L
R
1003
~~サブF/B 比例ゲインアップ~~
(0.1 → 0.2)
INCREASE ~~PROPORTIONAL~~ GAIN
1004
~~センサ出力変動積算~~
sdloxsl←Σ ΔV
1008
END
1005
~~センサ素子高温度制御~~
HIGH TEMP CONTROL ?
~~No~~ NO
~~Yes~~ YES
NO
1022
~~O2センサ出力~~<0.35v?
V1
~~Yes~~ YES
NO
1006
~~サブF/B 比例ゲインダウン~~
(0.05 → 0.1)
1007
~~センサ出力変動積算~~
sdloxsh←Σ ΔV
1023
~~サブF/B 比例ゲインセット~~
(~~リッチ~~:0.1, ~~リーン~~:0.05)
SET GAIN OF SUB F/B
R
L
INTEGRATE SENSOR OUTPUT VARIATION

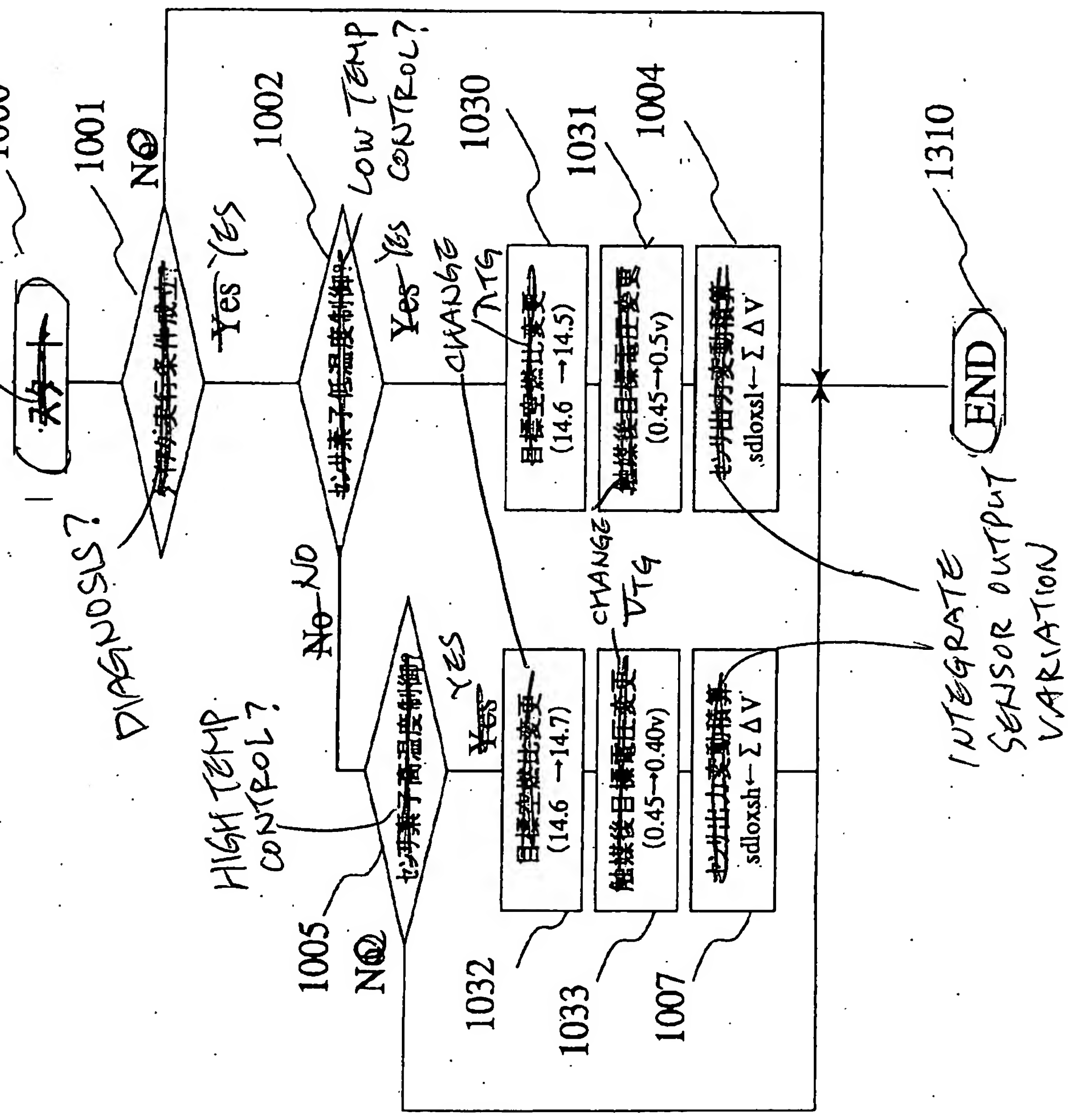
【図２１】

FIG. 21


t21 ~~T1~~
t22 ~~T2~~
t23 ~~T3~~
t24 ~~T4~~
t25 ~~T5~~
t26 ~~T6~~
t27 ~~T7~~
t28 ~~T8~~
ON
OFF
HIGH ~~高温~~
LOW ~~低温~~
~~通常~~ NORMAL
~~高温~~ HIGH
~~通常~~ NORMAL
700
540
400
~~ハイゲイン~~ HIGH GAIN
LOW GAIN ~~ローゲイン~~
sdloxsl
NORMAL
DETERIORATED
~~正常時~~
~~劣化時~~
~~正常時~~ NORMAL
~~劣化時~~ DETERIORATED
~~判定値~~
Y
pdloxs
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)

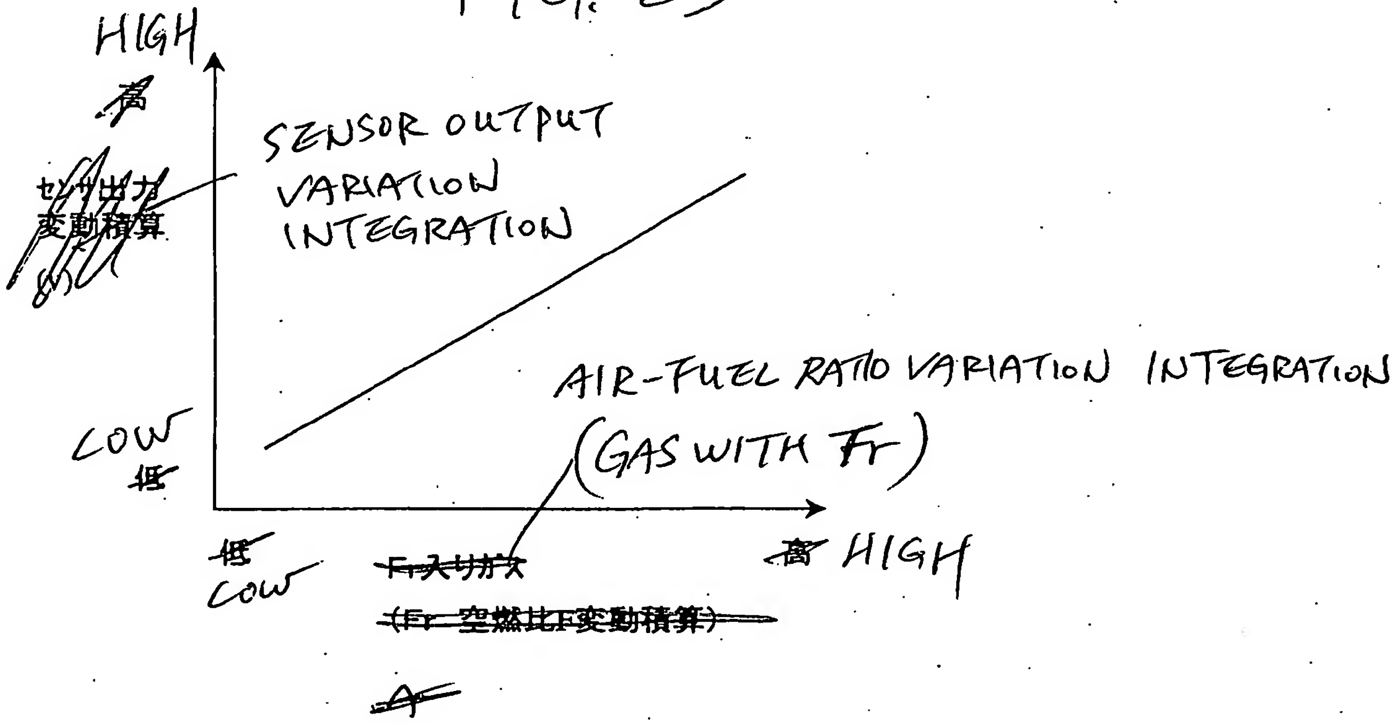
【図２２】

FIG. 22


1000
~~スタート~~
START
1001
~~異常判定実行条件成立~~
DIAGNOSIS?
NO
~~Yes~~ YES
1002
~~センサ素子低温度制御中~~
LOW TEMP CONTROL?
~~Yes~~ YES
No NO
1030
~~目標空燃比変更~~
(14.6 →14.5)
CHANGE λTG
1031
~~触媒後目標電圧変更~~
(0.45→0.5v)
CHANGE VTG
1004
~~センサ出力変動積算~~
sdloxsl←ΣΔV
1005
~~センサ素子高温度制御中~~
HIGH TEMP CONTROL?
~~Yes~~ YES
NO
1032
~~目標空燃比変更~~
(14.6 →14.7)
1033
~~触媒後目標電圧変更~~
(0.45→0.40v)
1007
~~センサ出力変動積算~~
sdloxsh←ΣΔV
INTEGRATE SENSOR OUTPUT VARIATION
1310
END

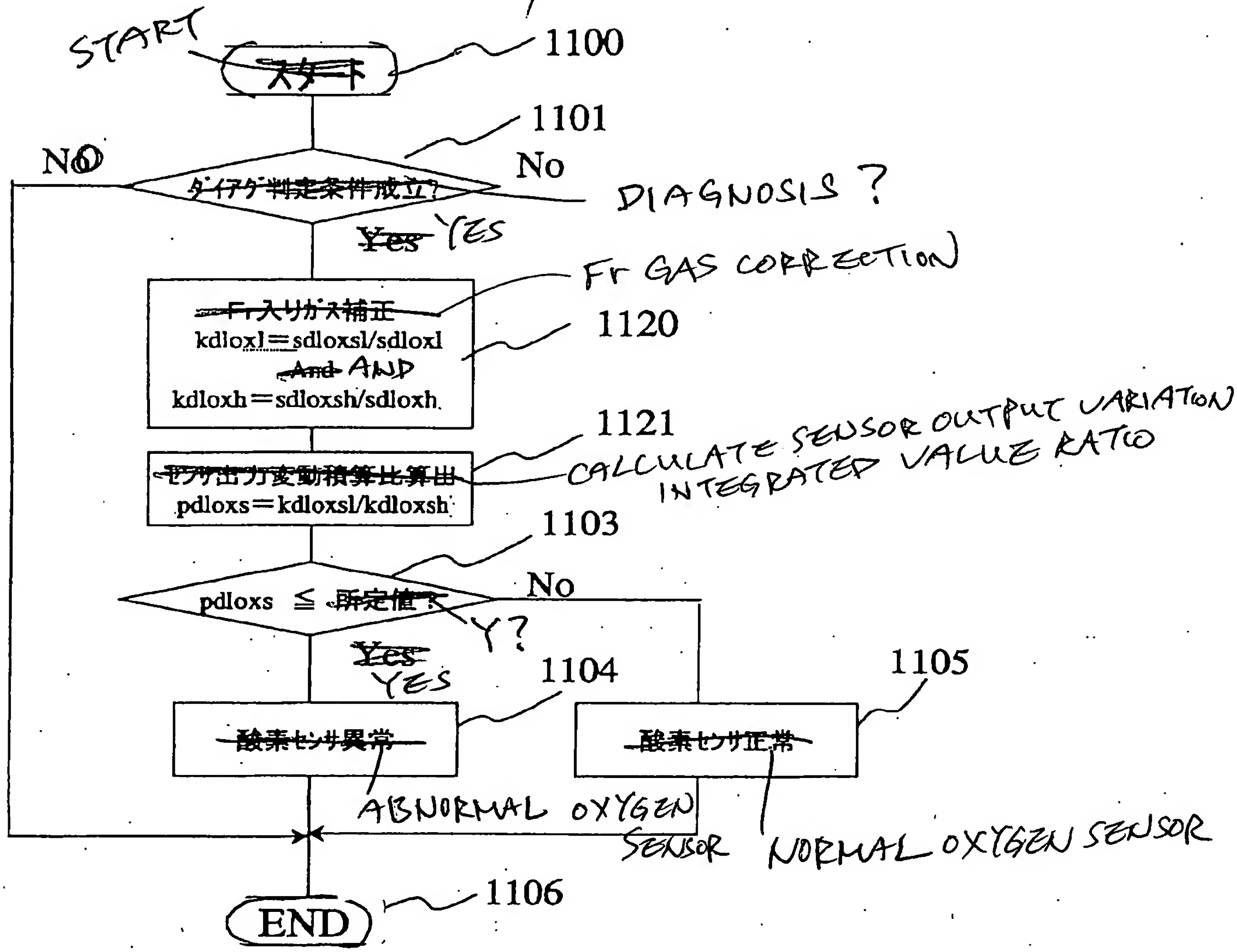
【図２３】

FIG. 23

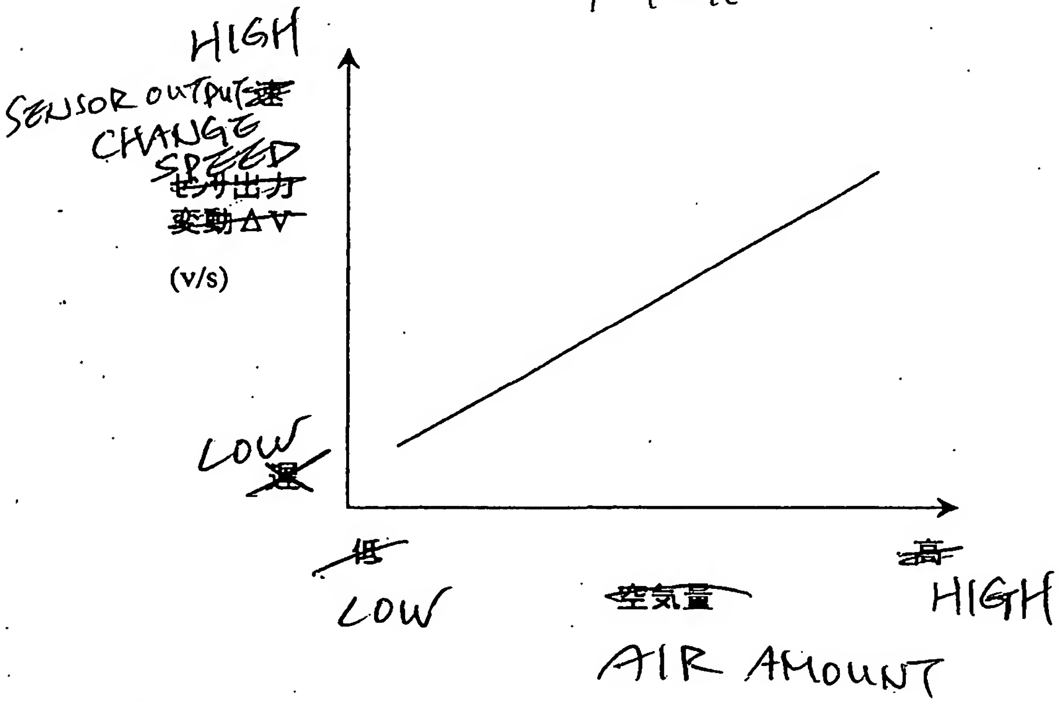

HIGH
~~高~~
~~センサ出力変動積算~~
SENSOR OUTPUT VARIATION INTEGRATION
LOW
~~低~~
~~低~~
LOW
~~高~~ HIGH
AIR-FUEL RATIO VARIATION INTEGRATION (GAS WITH Fr)
~~Fr入りガス~~
~~(Fr 空燃比F変動積算)~~
~~AF~~

【図２４】

FIG. 24


START
~~スタート~~
1100
1101
NO
No
~~ダイアグ判定条件成立?~~
DIAGNOSIS ?
~~Yes~~ YES
Fr GAS CORRECTION
~~Fr入りガス補正~~
kdloxl＝sdloxsl/sdloxl
~~And~~ AND
kdloxh＝sdloxsh/sdloxh
1120
1121
~~センサ出力変動積算比算出~~
CALCULATE SENSOR OUTPUT VARIATION INTEGRATED VALUE RATIO
pdloxs＝kdloxsl/kdloxsh
1103
pdloxs ≦ ~~所定値?~~ Y?
No
~~Yes~~ YES
1104
1105
~~酸素センサ異常~~
ABNORMAL OXYGEN SENSOR
~~酸素センサ正常~~
NORMAL OXYGEN SENSOR
END
1106

【図２５】 FIG. 25


HIGH
SENSOR OUTPUT ~~速~~ CHANGE SPEED
~~センサ出力~~
~~変動ΔV~~
(v/s)
LOW
~~遅~~
~~低~~
LOW
~~空気量~~
AIR AMOUNT
~~高~~
HIGH

English translation
(Machine translation) of
JP 7-198672A

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CLAIMS

[Claim(s)]
[Claim 1] In the equipment which diagnoses the life of the self-heating mold limiting current type oxygen sensor which consists of an oxygen ion conductivity solid electrolyte, and possesses a heater (a) The heater control means which switches the temperature of said oxygen sensor to normal operation temperature and a diagnostic operating temperature usually higher than temperature, (b) The trigger means which switches the operating temperature of said oxygen sensor to said diagnostic operating temperature from said normal operation temperature when the output value X of the oxygen sensor detected at said normal operation temperature carries out predetermined time continuation and is within the limits of predetermined, (c) A means to calculate difference |Y-X| of the output value Y of the oxygen sensor in said diagnostic operating temperature, and said output value X, (d) Life diagnostic equipment of the oxygen sensor characterized by providing a life diagnostic means to diagnose that said oxygen sensor is a life when the value of said difference |Y-X| is beyond a predetermined value.
[Claim 2] It is the life diagnostic equipment of the oxygen sensor characterized by said diagnostic operating temperature being temperature higher 5-30 degrees C than said normal operation temperature in the life diagnostic equipment of an oxygen sensor according to claim 1.
[Claim 3] Life diagnostic equipment of the oxygen sensor characterized by providing a means to control [second] change of operating temperature in 1 degree C /or less in the life diagnostic equipment of an oxygen sensor according to claim 1 or 2 when switching the operating temperature of said oxygen sensor further.
[Claim 4] Life diagnostic equipment of the oxygen sensor characterized by performing temperature compensation by operating temperature and providing a means to convert into an oxygen density in the life diagnostic equipment of an oxygen sensor according to claim 1 to 3 in case the output values X and Y of said oxygen sensor are converted into an oxygen density.
[Claim 5] Life diagnostic equipment of the oxygen sensor characterized by providing a means to hold and have the operating temperature of an oxygen sensor in said diagnostic operating temperature, and to make an oxygen sensor live long when it diagnoses that said oxygen sensor is a life in the life diagnostic equipment of an oxygen sensor according to claim 4.
[Claim 6] Life diagnostic equipment of the oxygen sensor characterized by providing a means to report the life of an oxygen sensor when it diagnoses that said oxygen sensor is a life further in the life diagnostic equipment of an oxygen sensor according to claim 1 to 5.
[Claim 7] said predetermined range [said output value X / on the life diagnostic equipment of an oxygen sensor according to claim 1 to 6, and] -- an oxygen density -- converting -- 19.6%-20.5%O2 it is -- said predetermined value [said difference |Y-X| / said predetermined time amount is 1 - 60 minutes, and] -- an oxygen density -- converting -- 0.1%-0.3%O2 it is -- life diagnostic equipment of the oxygen sensor characterized by things.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the life diagnostic equipment of the oxygen sensor which can measure an oxygen density continuously, without reducing the engine performance of a sensor in detail about the equipment which diagnoses the life of the self-heating mold limiting current type oxygen sensor used for an oxygen density monitoring device etc.
[0002]
[Description of the Prior Art] From the former, the limiting current type oxygen sensor (the following calls it an oxygen sensor) by the solid electrolyte is used focusing on the oxygen-deficiency alarm, the oxygen analyzer of industrial use, etc. However, the life of this oxygen sensor is short compared with the life of the equipment around it, and since there is dispersion in a life depending on an operating environment, fixed exchange of the sensor in consideration of an operating environment has been performed.
[0003] Although the life of this sensor is produced by the fall of the ionic conductivity of a solid electrolyte, and the fall of electrode ability, it is concluded that this reached when the minimum of the electrical-potential-difference range which gives the limiting current was mostly in agreement with the measurement electrical potential difference currently impressed to a sensor, as shown in drawing 8 .
[0004] As an approach of diagnosing the life of this sensor with equipment, choose the electrical potential difference of two points from the range of the electrical potential difference which gives the limiting current with the initial output characteristics of a sensor, and they are impressed by turns. the technique (JP,60-218058,A --) of diagnosing a degradation condition from the difference of the output current in the electrical potential difference of two points The technique (JP,61-212753,A, JP,4-264250,A) diagnosed from the two detection sections dedicated to JP,1-262460,A, the technique (JP,61-212753,A) diagnosed from the property at the time of starting of a sensor, two sensors, or one sensor is known.
[0005] The mutual change of the electrical potential difference of two points of the immobilization currently indicated by JP,60-218058,A and JP,1-262460,A, or by the technique of diagnosing a degradation condition from the difference of the output current by the sweep for two points of immobilization From generating of shooting of the output current, or fluctuation of the output current, in order to stop the original function of equipment at the time of a diagnosis and to judge from an output current difference, it is necessary to take the to some extent large electrical-potential-difference difference for two points, and there is a problem of diagnosing as a life by time amount shorter than a further original life.
[0006] by the technique diagnosed from the property at the time of starting of the sensor currently indicated by JP,61-212753,A, there is a problem that cannot perform application to what carries out prolonged continuation actuation, but a motive property changes with the time intervals from a halt to a reboot even when degradation extent is the same, and a starting performance changes under the effect of humidity.
[0007] By the technique in two sensors currently indicated by JP,61-212753,A, since the normal sensor used as criteria is needed and it becomes the diagnosis by the transient, there is a problem that it will not be able to include in equipment, either and it will be necessary it not only cannot to do simply, but to stop the original function of equipment at the time of a diagnosis.
[0008] By the technique diagnosed from the two detection sections dedicated to one sensor currently indicated by JP,4-264250,A, the detecting element prepared for the life diagnosis will need to make a limiting current value high from the purpose, and has the problem that a substantial life will become quite short.
[0009] Therefore, the purpose of this invention is offering the equipment which can judge the life of a sensor, without barring continuous running in an oxygen-deficiency alarm, the oxygen analyzer of industrial use, etc., without solving the above-mentioned problem and reducing the engine performance of an oxygen sensor component.

[0010]
[Means for Solving the Problem] When this invention person compares the output value in the usual operating temperature with the output value in a diagnostic operating temperature higher than normal operation temperature paying attention to the output value of an oxygen sensor increasing by the rise of operating temperature as a result of wholeheartedly research and the difference was searched for in view of the above-mentioned purpose, he discovered that the life of a sensor could be diagnosed, without checking the function of equipment original, and completed this invention.
[0011] Namely, the equipment which diagnoses the life of the self-heating mold limiting current type oxygen sensor which consists of an oxygen ion conductivity solid electrolyte of this invention, and possesses a heater (a) The heater control means which switches the temperature of said oxygen sensor to normal operation temperature and a diagnostic operating temperature usually higher than temperature, (b) The trigger means which switches the operating temperature of said oxygen sensor to said diagnostic operating temperature from said normal operation temperature when the output value X of the oxygen sensor detected at said normal operation temperature carries out predetermined time continuation and is within the limits of predetermined, (c) It is characterized by providing a means to calculate difference $|Y-X|$ of the output value Y of the oxygen sensor in said diagnostic operating temperature, and said output value X, and a life diagnostic means to diagnose that said oxygen sensor is a life when the value of (d) aforementioned difference $|Y-X|$ is beyond a predetermined value.
[0012]
[Function] According to the above-mentioned configuration, the life diagnostic equipment of the sensor by this invention acts as follows.
[0013] In a usual case, the operating temperature of a sensor is held by the heater currently formed in the sensor, and the heater control means at normal operation temperature. Fixed direct current voltage is impressed to the cel of a sensor, and the limiting current corresponding to an oxygen density is acquired by always [forward] as the output current of a sensor.
[0014] The output current of the sensor turns into the output current which shows an oxygen density lower about 0.5% to 1.0% than the oxygen density usually expected, and since it is thought that it is because the oxygen sensor became a life when it continues beyond a period with the output current, a life diagnosis is started. When the output value of the sensor under diagnostic operating temperature is detected, the difference of this and the sensor output value under normal operation temperature is searched for and a difference crosses the predetermined range after switching the operating temperature of a sensor to a diagnostic operating temperature higher than normal operation temperature by the heater control means and fully stabilizing operating temperature, it is judged that a sensor is a life.
[0015] Thus, a life diagnosis can be performed by diagnosing a life by changing the operating temperature of a sensor, without it becoming unnecessary to change the electrical potential difference impressed to the cel of a sensor, and barring the oxygen density measurement of a sensor. Moreover, in case the output current of an oxygen sensor is converted into an oxygen density, an always exact oxygen density can be displayed by amending change of the output value by operating temperature. Furthermore, by holding the operating temperature of the sensor judged to be a life to diagnostic operating temperature, measurement of an oxygen density is continuable also until it is exchanged in a sensor.
[0016]
[Example] The life diagnostic equipment of the limiting current type oxygen sensor by one example of this invention is explained with reference to the configuration block Fig. of drawing 1 . In the life diagnostic equipment of this example, the direct-current-voltage feeder 2 connected with the anode plate 111 of the cel 11 of a sensor 1, and current detection equipment 3 has connected with the cathode 112 of the cel 11 of a sensor 1. A microcomputer 5 serves as CPU51 from A/D converter 52 connected to it, D/A converter 53, ROM54 and RAM55, and an output port 56. It connected with current detection equipment 3 and CPU51, and the heater drive control unit 4 has connected A/D converter 52 to the heater 12 and D/A converter 53 of a sensor 1. The lamp 6 and LED display equipment 7 are connected to the output port 56 of a microcomputer 5.
[0017] According to the output voltage of D/A converter 53 of a microcomputer 5, by controlling the heater drive control unit 4, it adjusts and has the current which flows at the heater 12 on a sensor 1, and the operating temperature of a sensor is controlled. Drawing 2 shows an example of the heater drive control unit 4. The output voltage of D/A converter 53 passes along the operational amplifier A1 which wired with the voltage follower as a current buffer first, and the current which flows at a heater 12 is changed according to the output voltage of D/A converter 53 by the circuit which consists of an operational amplifier A2, transistors TR1 and TR2, and resistance R3, R4, and R5 next. Thereby, the operating temperature of a sensor 1 can be adjusted to a predetermined value.

[0018] In this invention, an oxygen sensor is operated with normal operation temperature and diagnostic operating temperature. Normal operation temperature is the operating temperature of the oxygen sensor in the normal state used for detecting an oxygen density, and, generally is 350 degrees C - 450 degrees C. Moreover, diagnostic operating temperature is temperature higher 5-30 degrees C than normal operation temperature. For the life of an oxygen sensor, an exact output value comes to be acquired at normal operation temperature by considering as a diagnostic operating temperature slightly higher than normal operation temperature by the case so that an exact output value may not be acquired.

[0019] the operating temperature of an oxygen sensor -- the diagnostic operating temperature from normal operation temperature -- or when [that] switching conversely, it is desirable to carry out change of operating temperature in 1 degree C/second or less. When change of operating temperature exceeds a second in 1 degree C /, the output of an oxygen sensor is changed sharply and exact oxygen density measurement becomes impossible. The change rate of operating temperature is easily controllable by adjusting the change rate of the output voltage of D/A converter 53.

[0020] Direct current voltage is impressed to the cel 11 of a sensor 1 by the direct-current-voltage feeder 2. In this example, although the direct current voltage of 1.4V is impressed to a sensor 1, this invention is not limited to this. Current detection equipment 3 detects the current which a sensor 1 outputs, and it is inputted into CPU51 through A/D converter 52. An example of current detection equipment 3 is shown in drawing 3 . After the output current of a sensor 1 is amplified by the amplifying circuit which is changed into an electrical-potential-difference value by resistance R6, and consists of operational amplifier A3, variable resistance VR 1, and resistance R7 and R8, it is inputted into A/D converter 52 and changed into digital value.

[0021] According to the program currently written in ROM9, the output value of the inputted oxygen sensor is written in RAM10, an operation, a comparison, etc. are performed, and an external instrument is controlled by CPU51 through an output port 56 and D/A converter 53.

[0022] The output value of the oxygen sensor inputted into CPU51 is converted into an oxygen density. Since the operating temperature of an oxygen sensor is changed as mentioned above, in this invention, it has a means to amend fluctuation of the oxygen sensor output value accompanying fluctuation of operating temperature. The ratio of the output value of an oxygen sensor to the gas of the same oxygen density in normal operation temperature and diagnostic operating temperature uses the property of being the same, and, specifically, prepares the correction factor of operating temperature. The value of the correction factor in each temperature is calculated beforehand, and an oxygen density is calculated by calculating from the output value and correction factor which CPU51 incorporated. The value of this oxygen density passes along an output port 56, and is displayed on LED display equipment 7.

[0023] The main motions of the control program currently written in ROM9 are explained below. First, a correction factor is set to 1 by the value corresponding to normal operation temperature, and this example. And a diagnostic flag is made into the value which usually expresses a measurement condition, 0 [for example,]. Subsequently, the output value of an oxygen sensor is inputted and it judges whether the output value of an oxygen sensor is stable within the limits of predetermined.

[0024] The predetermined range is the range of the value expected to output when an oxygen sensor becomes a life. When an oxygen sensor becomes a life, specifically, it is common that the output value declines. then, the usual oxygen density of **-ed gas -- 0.5%O2 -1.0%O2 extent -- period [a period when a low output value is fixed], for example, when it continues for [1 minute -] 60 minutes, let this be the trigger of life diagnostic initiation of an oxygen sensor. The above-mentioned predetermined range can be beforehand set as arbitration by the oxygen density of **-ed gas. For example, when it is the measuring object about the oxygen density in atmospheric air, the minimum of this predetermined range sets to O2 (oxygen density conversion) 19.0 to 20.0%, and it is desirable that an upper limit sets to O2 (oxygen density conversion) 20.0 to 20.8%.

[0025] Moreover, in order to judge whether the output value of an oxygen sensor is stable, the absolute value of the difference of the output value of an oxygen sensor and the output value in front of one (or partly front output value) is calculated first. It crosses during [total / of 1 minute -] a period when the absolute value of a difference is fixed, for example, 60 minutes, and is O2 0.3%. If it is the following (oxygen density conversion), it will be judged that the output value of an oxygen sensor is stable.

[0026] If a life diagnosis of an oxygen sensor begins, CPU51 will switch the operating temperature of an oxygen sensor 1 for data to D/A converter 4 through delivery and the heater drive control unit 4 at diagnostic operating temperature at diagnostic operating temperature. In connection with it, an operating-temperature correction factor is made into the value corresponding to diagnostic operating temperature, and a diagnostic flag is set to 1 by the value and this example which show a life diagnostic state.

[0027] The output value of an oxygen sensor just before switching operating temperature to diagnostic operating temperature is set to X, and it incorporates from A/D converter 52, and memorizes to RAM55. And the output value of the oxygen sensor immediately after completing a switch of operating temperature is memorized as Y. As a means to judge termination of this operating-temperature switch, it switches from the temperature gradient and switch rate of diagnostic operating temperature and normal operation temperature, a duration is calculated beforehand, and the means in comparison with the internal clock of a microcomputer 5 or a means to count the number of counts equivalent to said switch duration is mentioned.

[0028] When the value of formula |Y-X| is calculated and a value becomes using X and Y which were obtained beyond a predetermined value, it is judged that an oxygen sensor is a life. This predetermined value is O2 0.1% O 2 to 0.3%. Carrying out is desirable. However, X and Y are the oxygen density values calculated using both the correction factors of operating temperature. A predetermined value is O2 0.1%. There is a possibility of causing an incorrect diagnosis, in the following. When an oxygen sensor is judged to be a life, CPU51 outputs a signal to an output port 56. This signal makes a lamp 6 turn on through an output port 56, and it reports that the oxygen sensor became a life.

[0029] When an oxygen sensor is judged not to be a life, the operating temperature of an oxygen sensor is switched to normal operation temperature, a correction factor is made into the value corresponding to normal operation temperature, and a diagnostic flag is set to 0.

[0030] Although the life of an oxygen sensor is diagnosed with the equipment mentioned above in this invention, the configuration of further the following can be added to the above-mentioned equipment.

[0031] When an oxygen sensor is judged to be a life, operating temperature of an oxygen sensor is made into diagnostic operating temperature, the correction factor of operating temperature is left the value corresponding to diagnostic operating temperature, a diagnostic flag is set to 0, and measurement of an oxygen density is continued. With this means, also after diagnosing as a life, exact oxygen density measurement can be performed with diagnostic operating temperature until a sensor is exchanged, and interruption of a measurement function escapes.

[0032] Moreover, after switching the operating temperature of an oxygen sensor to normal operation temperature, without diagnosing as a life immediately when the value of said formula |Y-X| is beyond a predetermined value in order to perform a life diagnosis to accuracy more, the output value of an oxygen sensor is inputted, it considers as X', and the value of formula |Y-X'| is calculated. | When the value of Y-X'| becomes beyond the above-mentioned predetermined value, judge that an oxygen sensor is a life. With this means, an incorrect diagnosis can be avoided and a more exact life diagnosis can be performed.

[0033] A motion of a control program is explained with reference to drawing 4 which is the example, and 5. If equipment is started, the correction factor of operating temperature will be set to 1, and a diagnostic flag will be set to 0 (step 1). The operating temperature of a sensor is set to normal operation temperature through D/A converter 53 (step 2). And step 3 is repeated until the operating temperature of a sensor 1 becomes stability.

[0034] When the operating temperature of a sensor 1 is stabilized, the output value of a sensor is incorporated first (step 4), an oxygen density is calculated using the correction factor of operating temperature etc., and it is made to display on LED display equipment 7 (step 5). In addition, at step 5, it can have well-known functions, such as an oxygen density alarm, besides the above. Next, a diagnostic flag is checked, if it is not 0, it will go into step 15 of diagnostic routine, and if it is 0, it will progress to the stable decision routine of an output value (step 6). (from step 7)

[0035] By the stable decision routine of an output value, it judges whether the output value of a sensor is within the limits of predetermined first (step 7). If the output value is not contained in the predetermined range, a count is set to 0 (step 14) and it returns to step 4. If an output value is predetermined within the limits, it will be confirmed whether the output value of a sensor is stable (step 8). With [as compared with the last output value / the absolute value of the difference] two [or less / 0.3% O] (oxygen density conversion) for the output value of a sensor, 1 is added to a count (step 9), and if the absolute value of a difference exceeds O2 (oxygen density conversion) 0.3%, it will progress to step 10.

[0036] Subsequently, the value and constant 1 of a count are compared (step 8). If a count is less than one constant, it will return to step 4. On the other hand, if counts are one or more constants, the output value of a sensor will be set to X (step 11), the correction factor of operating temperature will be set to 0.975 by the value corresponding to diagnostic operating temperature, and this example, and a diagnostic flag will be set to 1 (step 12). And the operating temperature of a sensor is set to diagnostic operating temperature (step 13), and it returns to step 4.

[0037] When a diagnostic flag is 1, processing goes into diagnostic routine from step 6. 1 is first added to a count (step 15), and a count is compared with a constant 2 (step 16). If a count is less than two constant, if return and counts are two or more constants, the output value of an oxygen sensor will be incorporated to step 4, and it will be referred to as Y at it (step 17). And the value and predetermined value of formula |Y-X| are compared (step 18). If the value of formula |Y-X| is under a predetermined value, a diagnostic flag will be set to 0 (step 21), and a count will be set to 0 by making operating temperature of an oxygen sensor into an operating temperature of operation (step 22) (step 23), and it will return to step 4 1 which is a value corresponding to normal operation temperature for the correction factor of operating temperature. It diagnoses that an oxygen sensor is a life if the value of formula |Y-X| is beyond a predetermined value, and make the lamp which reports the life of a sensor turn on (step 19), set the correction factor of operating temperature to 0.975 which is a value corresponding to diagnostic operating temperature, and it carries out by setting a diagnostic flag to 0 (step 20), returns to step 4, and measurement of an oxygen density is continued.

[0038] In the above-mentioned control program, it can have the input means of a constant value everywhere by the still better known approach.

[0039] According to the above-mentioned configuration, the life diagnostic equipment of the sensor by this invention can diagnose the true life of the oxygen sensor from which oxygen density change and the incorrect diagnosis by malfunction of equipment were excepted, without checking the original function of an oxygen sensor by switching the operating temperature of an oxygen sensor 1 between normal operation temperature and diagnostic operating temperature, and comparing the difference and predetermined value of an output of an oxygen sensor in both operating temperature. Moreover, by making into diagnostic operating temperature operating temperature of the oxygen sensor judged to be a life, by the time it is exchanged, the prolongation of life of a sensor can be aimed at, and interruption of oxygen density measurement can be avoided.

[0040] The life diagnosis of a limiting current type oxygen sensor was performed using the equipment shown in example 1 above-mentioned drawing 1 -5. Reference voltage V1 was set to 1.4V. Normal operation temperature was made into 420 degrees C, and diagnostic operating temperature was made into the temperature which added 10 degrees C to normal operation temperature. The correction factor of normal operation temperature was set to 1, and the correction factor of diagnostic operating temperature was set to 0.975. The constant 1 of step 10 in drawing 4 was set to 300 (it corresponds in 5 minutes.), and set the constant 2 of step 16 of drawing 5 to 60 (it corresponds in 1 minute.). It converts into an oxygen density and the predetermined value in step 18 is O2 0.2%. It carried out.

[0041] The oxygen sensor 1 in the early stages of operation usually reaches, the voltage-current property of diagnostic operating temperature is shown in drawing 6 , and the voltage-current property when being judged as a life is shown in drawing 7 . As shown in drawing 6 and 7, the life diagnostic equipment by this invention has judged the exact life of an oxygen sensor 1. Moreover, also by the sensor judged to be a life, in diagnostic operating temperature, the electrical potential difference which gives the limiting current is still low fully, and exact oxygen density measurement can be performed so that drawing 7 may show.

[0042] As mentioned above, although this invention was explained using the example, unless this invention deviates from the main point of not only this example but this invention, it is possible to make various change.

[0043]

[Effect of the Invention] If the life diagnostic equipment of the oxygen sensor of this invention is used as explained above, the exact life of a sensor can be judged, and the effect which a life diagnosis has on oxygen density detection is very small, and has extent which can be disregarded. Moreover, it can be made to live long also by the sensor diagnosed as the life. Therefore, the life of a sensor can be judged correctly, without stopping the main function of an oxygen-deficiency alarm or the equipment of an industrial use oxygen analyzer.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the configuration of the life diagnostic equipment of the oxygen sensor by one example of this invention.
[Drawing 2] It is the circuit diagram showing the configuration of the heater drive control unit by one example of this invention.
[Drawing 3] It is the circuit diagram showing the configuration of the current detection equipment by one example of this invention.
[Drawing 4] It is the flow chart which shows the flow of processing of the life diagnostic equipment of the oxygen sensor by one example of this invention.
[Drawing 5] It is the flow chart which shows the flow of processing of the life diagnostic equipment of the oxygen sensor by one example of this invention.
[Drawing 6] It is the graph which shows the voltage-current property in early stages of the sensor in one example of this invention.
[Drawing 7] It is the graph which shows the voltage-current property at the time of the life of the sensor in one example of this invention.
[Drawing 8] It is the graph of the voltage-current property of expressing the degradation property of the limiting current type oxygen sensor set as the object of the life diagnostic equipment of the oxygen sensor of this invention.

[Translation done.]